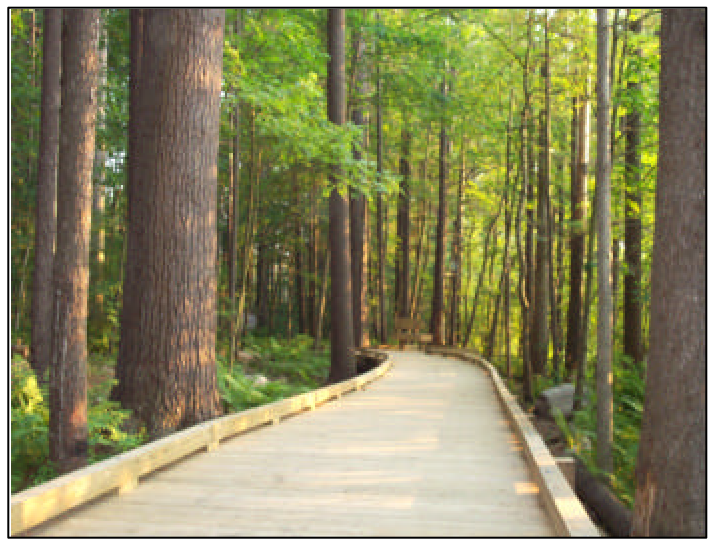
MANCHESTER URBAN PONDS RESTORATION PROGRAM

YEAR 5 REPORT 2004

ART GRINDLE
Program Coordinator

&

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Manchester Conservation Commission

April 2005

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A Note About This Publication

The text from Section IV(Water Quality Analysis of Manchester's Urban Ponds) was largely taken from the Volunteer Lake Assessment Program's bi-annual water quality reports. The associated water quality graphs following analysis are taken directly from these reports. Special thank you to Andrea Lamoreaux (VLAP Coordinator) for use of the information in this report.

Cover Photos

Left: Dorrs Pond, by Art Grindle
Right: Dorrs Pond Boardwalk, by Jen Drociak

ACKNOWLEDGEMENTS

The authors would like to thank the following people for their assistance throughout the last five years:

Manchester Conservation Commission: Todd Connors, Jen Drociak, Marty Gavin, Kathleen Neville, JoAnn O'Shaughnessy, Michael Poisson, Eric Skoglund.

City of Manchester: Rick Cantu, Marty Gavin, Ron Johnson, Joanne McLaughlin, Department of Planning and Community Develpoment.

Department of Environmental Services: Andy Chapman, Jody Connor, Steve Couture, Walt Henderson, Andrea LaMoreaux, Steve Landry, Stephanie Lindloff, Amy Smagula, Ken Warren. Thank you to the summer interns in the DES Limnology Center who ran the water samples during field season, and to personnel in the Laboratory Services unit at DES who also participated in running water samples.

SEPP Advisory Committee and Associates: Cyndy Carlson, Andy Chapman, Carl DeLoi, Trish Garrigan, Tom Siegle, Eric Williams.

Urban Ponds Restoration Program Interns: 2001: Kat St. Jean; 2002: Lydia Henry; 2003: Emily Welch.

Black Brook Advisory Committee: Art Grindle, Jen Drociak, Ron Johnson, Steve Landry, Grace Levergood, Stephanie Lindloff, Jim MacCartney, Kathleen Neville, Margaret Watkins.

Comprehensive Environmental (CEI): Rebecca Balke, Ben Lundsted, Eileen Pannetier.

Friends: Jane Beaulieu (For Manchester)

Crystal Lake Preservation Association (CLPA) including Ken Cardin, J. Andrew Manning, and Robert Corbeil.

Dorrs Pond Preservation Society (DPPS) including Terri Duminsil, Rita Espinoza, and Blanche Grondin.

Pine Island Pond Environmental Society (PIPES) including Merrill Lewis, David Erickson, Carole Lessard, and Brendan Daley.

Thank-You to all of our Cleanup Volunteers!

2000: Todd Baril, Matt Barrett, Leslie Barrett, Donald Bouchard, Bill Boyd, Cyndy Carlson, Amanda DeSantis, Jen Drociak, Rich Duport, Rita Espinoza, Roger Gamache, Rich Girard, Louella Grindle, Blanche Grondin, Scott Grondin, Will Infantine, Liz Jestude, Chris Kfoury, Barrett Kimball, Eric Lamper, Devin Martin, Joanne McLaughlin, Steve McLaughlin, Frank Norris, Ann Piekarski, Richard Piroso, Mary Ralbovosky, Jim Robinson, Avery Sinclair, Steve Smith, Sonja Tashin, Keith Zimmerman.

2001: Sudip Adhikan, Doug Burns, John Burns, Laura Burns, Ken Cardin, Cyndy Carlson, Steve Couture, Terri DeLangis, Brian Dodge, Jen Drociak, Rita Espinoza, David Ferrarini, Ryan Girard, Louella Grindle, Blanche Grondin, Meena Gywali, Riley Harris, Eric Laaberge, Alix Laclair, Andy Manning, Jim McLean, Dan Meagher, Tim Meagher, Tom Mulroy, Beth O'Neil, Robert Rivet, Tim Searles, Eric Skoglund, Marie Thibault, Nate Thibault, Kevin Urban, Paul Urban, Brenden Vesci, Matt Woodbury.

2002: John Angelo, Cyndy Carlson, Steve Couture, Jen Drociak, Kristina Drociak, Rita Espinoza, Armand Forest, Marty Gavin, Louella Grindle, Blanche Grondin, Riley Harris, Zane Knoy, Joanne McLaughlin, Nicole Minehart, Eric Skoglund, Mark Saltmarsh.

2003: Emily Burr, Christos Chakas, Andy Chapman, Heidi Clark, Pat Driscoll, Jen Drociak, Christa Elliott, Rita Espinoza, Greg Gauthier, Chris Goudreault, David Goudreault, Margorie Goudreault, Marty Gavin, Louella Grindle, Blanche Grondin, Norman Horion, Liz Jestude, Pete Martineau, Lowell McPherson, Brandon Meehan, Candace Puchaz, Carolyn Puchaz, Bob Shaw, Scott Shephard, Rob Sinclair, Steven Smith, Phyllis Stewart, Gail Trimbur, Claude Venna, Steve Viggiano.

2004: Emily Burr, George Burr, Christos Chakas, Andy Chapman, Karen Drapeau, Pat Driscoll, Jen Drociak, Terri Dumensil, Rita Espinoza, Sandy Finn, Greg Gauthier, Marty Gavin, Blanche Grondin , Andrea Hoben, Liz Jestude, Matt Kilrain, Mike MacDonald, Ruth Mac Donald, Sonya Martineau, Lowell McPherson, Elana Pachos, Josh Pratt, Eric Skoglund, Gail Trimbur, Ann Walls, Eric Williams.

Thank You to our Water Quality Monitoring Volunteers!

INTRODUCTION

Since 2000, the Manchester Urban Ponds Restoration Program (UPRP) has been overseen by the Manchester Conservation Commission (MCC) and has been part of a greater environmental effort in Manchester. As part of a solution to address Manchester's combined sewer overflows (CSOs) and improve environmental conditions within the city, six (6) Supplemental Environmental Projects (SEPs) were implemented. These projects are: Environmental Education Curriculum Development, Children's Environmental Health Risk Reduction, Stormwater Management, Streambank Stabilization, Land Preservation, and the Urban Ponds Restoration Program. The UPRP was established to assess the condition of seven of Manchester's urban ponds (Crystal Lake, Dorrs Pond, Maxwell Pond, McQuesten Pond, Nutts Pond, Pine Island Pond, and Stevens Pond), and to improve their water quality.

The primary **Goal** of the UPRP is:

- To attempt to return the ponds to their historic uses (such as boating, fishing or swimming).

The primary **Objectives** to meet that goal are:

- To promote public awareness, education, and stewardship;
- To reduce pollutant loading and nutrient inputs in order to improve water quality;
- To maintain or enhance biological diversity; and
- To provide improved recreational uses.

Manchester's urban ponds are quite different from one another and face unique challenges posed by the urban landscape that surrounds them. To better understand each pond, the UPRP has gathered baseline water quality and biological data over the past four years, and has identified water quality threats and trends at each pond. The current water quality is described in Section IV.

In April 2002 members of the Manchester Conservation Commission met with the Urban Ponds Restoration Coordinator to establish pond "goals" and project "prioritization." Each of the seven ponds was discussed at length with regards to potential water quality improvements, outreach/education opportunities, recreational opportunities, land preservation opportunities, and other management objectives. The result is a clearly defined set of goals and prioritized projects within each of the aforementioned categories. The list was revised in April 2003 and can be found in Section V.

For more information on any of these projects, please contact the Urban Ponds Restoration Coordinator at (603) 624-6450 or agrindle@ci.manchester.nh.us or visit http://www.manchesternh.gov/UrbanPonds.

SECTION I. WORK PLAN & AREAS OF FOCUS FOR 2003-2004

SECTION I. WORK OBJECTIVES (GENERAL)

1. **Water Quality:** Gain and report a better understanding of water quality in several parameters at each pond.
2. **Outreach/Education:** Promote community awareness and generate involvement in Manchester's urban ponds.
3. **Restoration Projects:** Develop and implement restoration projects at each pond.
4. **Aesthetics/Recreation:** Remove debris from ponds, work to create/retrofit pond areas as pleasant recreational places.
5. **Partnerships/Visioning:** Establish relationships and work with partners from municipal, state, and federal agencies to generate ideas and ensure programmatic understanding.

SECTION II. JOB DUTIES (SUPPORT WORK OBJECTIVES)

1. **Water Quality:** Continue collecting data and maintaining a water quality and biological "database" (Begin analyzing/interpreting/summarizing/reporting data.

2. **Outreach/Education:** Place more emphasis on outreach/education for the next two years. Enlist help of conservation commissioners and existing environmental groups in town as necessary.

3. **Restoration Projects:** Prioritize and balance pond restoration projects for each pond in three categories: Water Quality Improvement, Outreach/Education, and Recreation. Use MCC document to prioritize/report/plan projects.

4. **Aesthetics/Recreation:** Hold bi-annual pond cleanups, assist Parks & Recreation with conceptual trail work & kiosk construction/retrofit, and assist with other activities at each pond.

5. **Partnerships/Visioning:** Work closely with the Manchester Conservation Commission, Planning Department, Environmental Protection Division, SEPP Advisory Committee, and other state and federal officials.

SECTION III. KEY ASSIGNMENTS (SPECIFIC)

1. **Water Quality**

- Continue sampling each pond on a regular basis (at least once a month April-October).
- Seek additional opportunities for more advanced chemical, biological sampling/surveying (i.e. additional sediment depth sampling, macroinvertebrate sampling, fish surveys, bird surveys, etc).
- Continue systematically adding data into database and interpreting data.
- Summarize and report data and trends in a meaningful way so
  - i. Stake holders (including MCC, SEPP and public) can understand and take any appropriate action.
  - ii. Restoration projects at the ponds are properly prioritized and implemented.
  - iii. Summarized data is available for "measurable results" type documents, sampling data and cleanup volumes.

2. **Outreach/Education**

- Find new and innovative ways to disseminate information to the public.
- Coordinate a core group of volunteers for pond cleanups and water quality sampling.
- Give presentations at local middle schools, high schools, colleges, and other groups.
- Hold other pond activities/events.
- Produce a bi-annual newsletter (Late Spring, Early Fall)
- Create additional fact-sheets for public dissemination.
- Create and update website.
- Create and distribute annual report.
- Keep kiosk materials current.
- Work more closely with media (Union Leader, Hippo Press, WMUR, etc).

3. **Restoration Projects**

- Prioritize and balance pond restoration projects for each pond in three categories: Water Quality Improvement, Outreach/Education, and Recreation.
- Utilize "Pond Project Prioritization" document created with Manchester Conservation Commission in January 2002 as a guideline.
- Solicit input from municipal, state, federal agencies and well as the public.
- Publicize efforts and accomplishments (pond projects, grant monies received, etc).
- Forward communications from CEI and DES relevant to the ponds to Conservation Commission & EPD, to help keep both groups better informed of progress.

6. Aesthetics/Recreation

- Continue holding cleanups, trailwork, and other events at each pond.
- Track volumes of trash collected at each pond. Keep good records of volunteers attending and volume/type of trash collected. I.e. 3 bags of trash (mostly paper), 2 tires and 1 refrigerator. Also track partners, ie. trash pickup by City.
- Publicize cleanups and other events via e-mail distribution list, newsletter, website, press releases, flyers at kiosks, etc.

7. Partnerships/Visioning

- Submit weekly progress reports to Conservation Commission (cc EPD) including major weekly activities for Art and any meetings (attendees and topics), sampling, cleanups, etc.
- Progress report should also include HELP NEEDED section, which should be a list of current or upcoming tasks/projects that Art would like to solicit input.

- Attend information-sharing and collaborative/brainstorming meetings with key partners (Conservation Commission, Environmental Protection Division, Planning Department, SEPP Advisory Committee, Department of Environmental Services, etc)
- Attend SEPP Advisory Committee meetings and Conservation Commission meetings with program updates, items for action, and needed assistance.
- Brainstorm innovative ideas for outreach/education, and new projects.
- Keep Conservation Commission informed of weekly schedule (especially during Summer).
- Create tentative summer sampling/activity schedule and distribute to Conservation Commission.
- Create annual scope, in conjunction with Conservation Commission, with activities planned for each month. Include activities completed in weekly update.
- Meet with direct supervision at least once per month with the goal of meeting more often.
- Meet with other Conservation Commission supervisors more frequently/regularly and utilize their skills/experience when needed.
- Attend Planning Board staff meetings with program updates and keep Planning Board administrative assistants aware of your schedule.
- Distribute important documents (ie, outreach/education, newsletters, reports, etc) to Conservation Commission for review

SECTION II. OUTREACH & EDUCATION ENDEAVORS

Bi-Annual Pond Cleanups (Spring & Autumn)

Spring clean-up at Maxwell Pond.
Photo by Art Grindle.

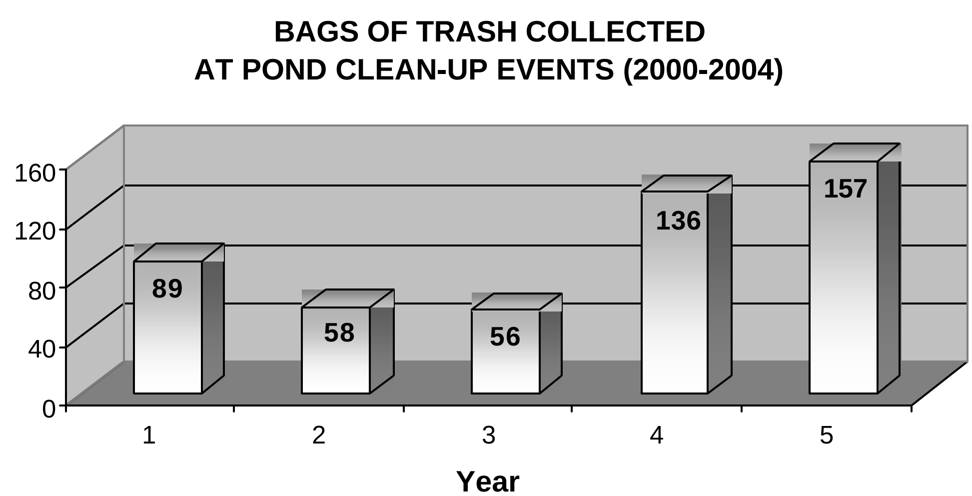
In 2004, the UPRP hosted cleanups at the following ponds: Dorrs Pond, Maxwell Pond, McQuesten Pond, Nutts Pond, and Stevens Pond. All 5 ponds were cleaned once during the spring (May/June), and once during the autumn (September/October) except for Dorrs Pond for a total of 10 cleanup events.

Through the year, 36 individual volunteers spent 185.50 hours collecting 201 bags of trash. The value of this volunteer time (www.independentsector.org) at $17.22/hour equates to $2,781.03 for 2004.

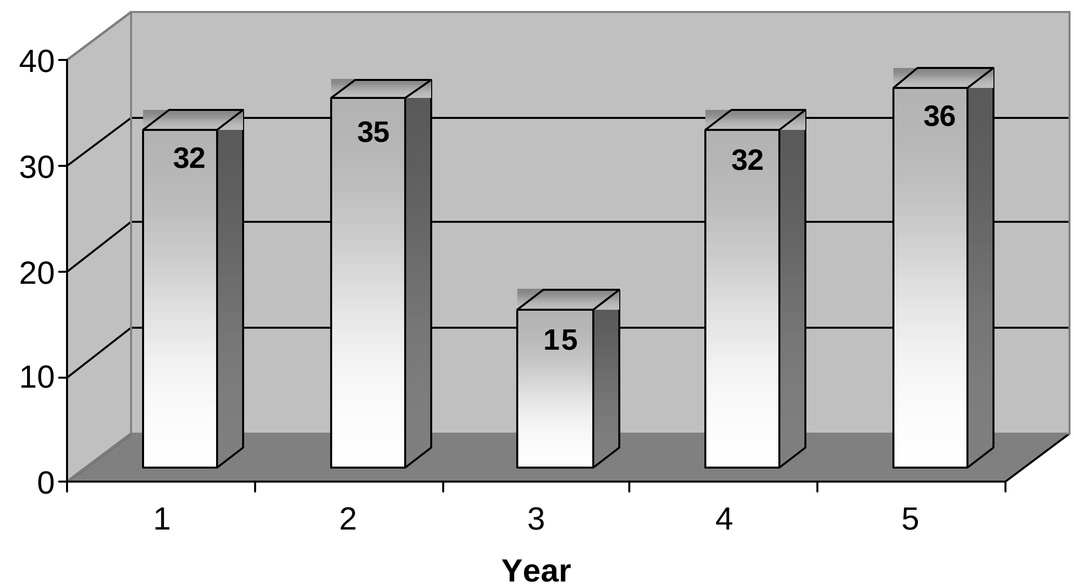
During 2004 volunteers also collected the most bags of trash and the UPRP generated the greatest number of volunteers and volunteer hours.

Table 1: 2004 Pond Clean Up Results

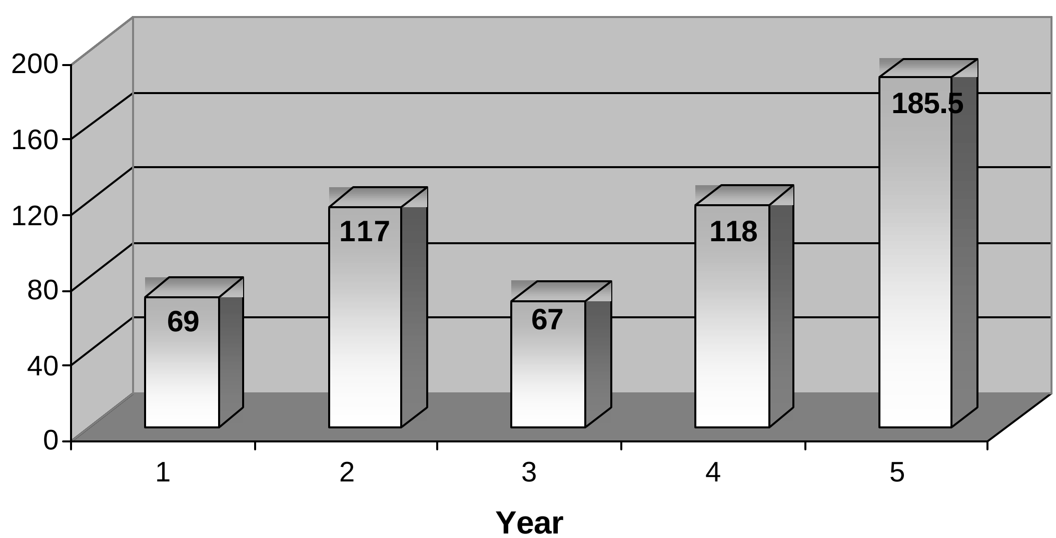
Clean-Up Location	Date of Event	Hours at Event	Bags of Trash Collected	Pounds of Trash	Volunteers In Attendance	Volunteer Hours	Value of Volunteer Time ($17.22/hr)
Maxwell Pond	4/17/2004	3.0	26	900	8	17	$292.74
McQuesten Pond	4/24/2004	3.0	30	2,340	14	30	$516.60
Dorrs Pond	5/1/2004	2.0	5		9	21	$361.62
Stevens Pond	5/8/2004	2.0	20	700	5	11	$189.42
Nutts Pond	5/15/2004	3.0	29	1,100	11	44.5	$766.29
		13.0	**110**	**5,040**	**26**	**147.5**	**$2,126.67**
Maxwell Pond	9/19/2004	3.0	6	120	2	6	$103.32
Stevens Pond	9/23/2004	2.0	8	80	4	8	$137.76
McQuesten Pond	10/2/2004	3.0	10	100	4	9	$154.98
Nutts Pond	10/16/2004	2.5	23	220	6	15	$258.30
		10.5	**47**	**520**	**16**	**38**	**$654.36**
		23.5	**157**	**5,560**	**42**	**185.5**	**$2,781.03**



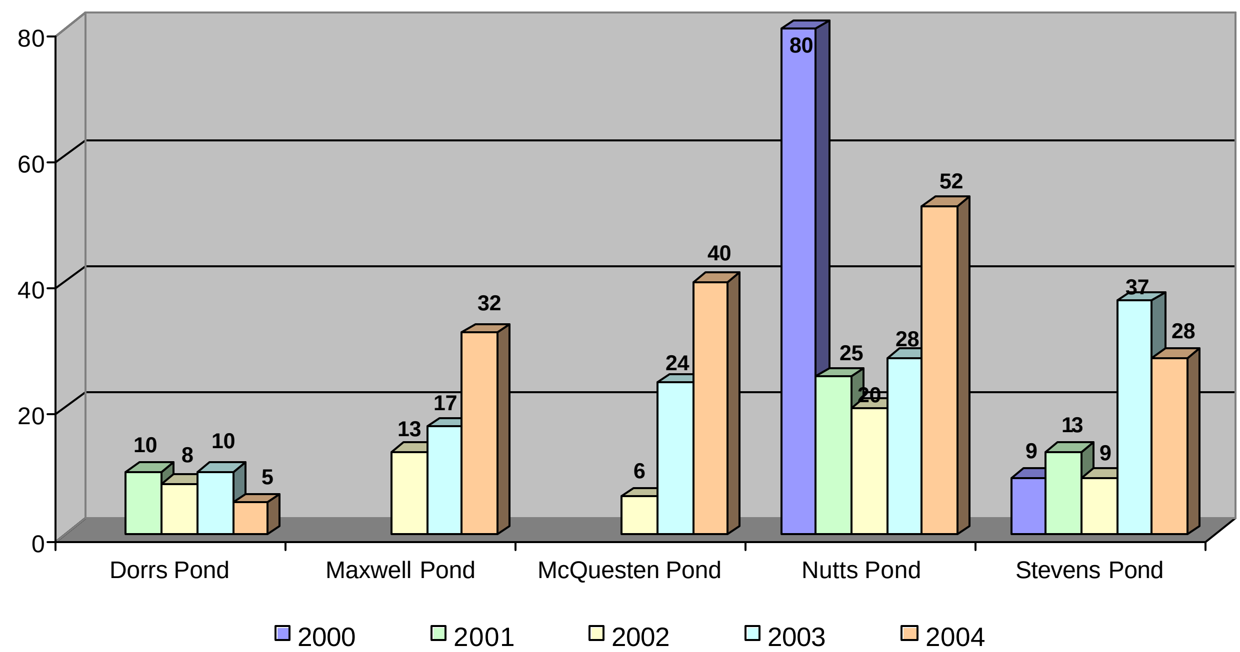
**TOTAL NUMBER OF VOLUNTEERS
AT POND CLEAN-UP EVENTS (2000 - 2004)**



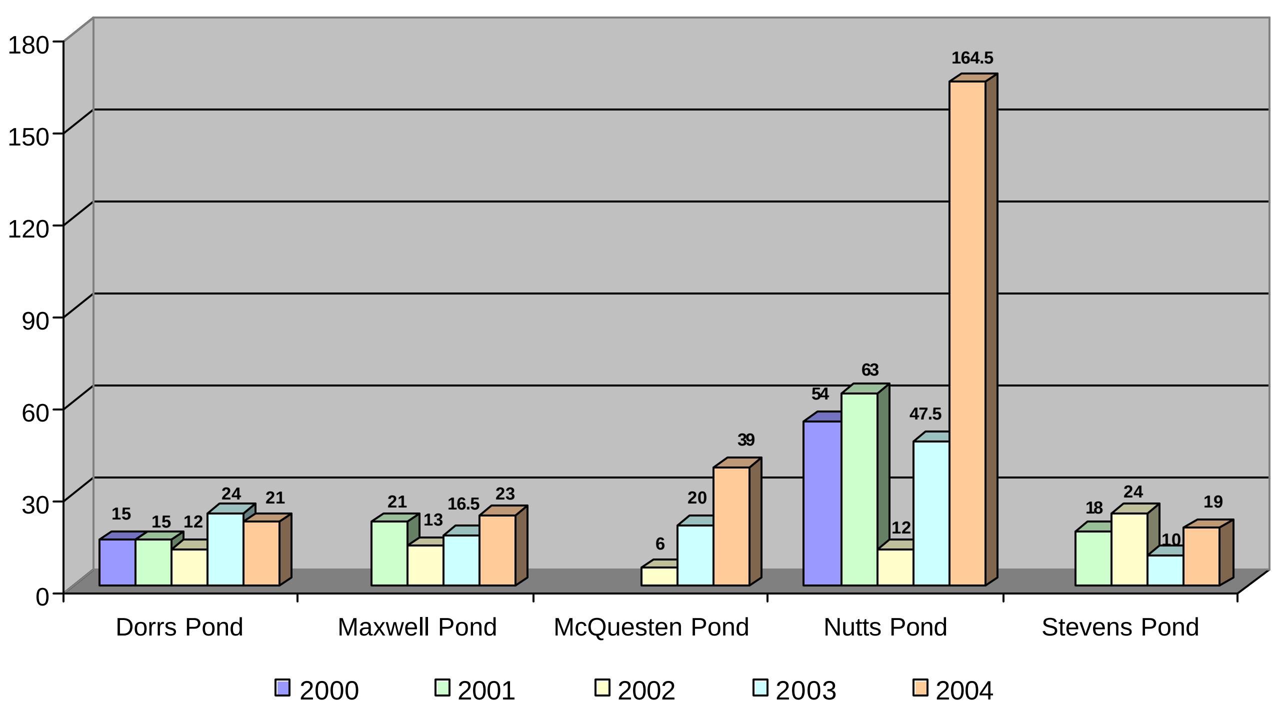
**TOTAL VOLUNTEER HOURS
AT POND CLEAN-UP EVENTS (2000 - 2004)**



BAGS OF TRASH COLLECTED PER POND (2000 - 2004)



VOLUNTEER HOURS PER POND (2000 - 2004)



Presentations, "Traveling Display", and Information Dissemination

In 2004, Jen Drociak and Art Grindle spent **38.5 hours** at events (and kept the display at several locations unattended) distributing **876 publications**. Publications include the UPRP brochure, SEPP brochure, Common Exotic Plant fact-sheets, Common Fish fact-sheets, History fact-sheets, Pond fact Sheets, "Pond Possibilities" newsletter, clean-up post-cards, and other items. Following is a description of each event.

UPRP Traveling Display. Photo by Jen Drociak

- **January 21 – March 5, 2004: 288 publications** were distributed at UNH Manchester where the display was located during this time.

- **February 5, 2004: 65 publications** were distributed at the For Manchester annual meeting where Art Grindle gave a presentation to recruit volunteers and raise awareness of the UPRP.

- **March 9 – April 16 2004: 94 publications** were distributed at the Manchester Public Library West were the display was located during this time.

- **April 23, 2004:** Jen Drociak and Art Grindle gave a presentation at the second annual **"Manchester Earth Day Forum"** which was held at the PSNH Energy Park in Manchester. **21 publications** were distributed at this event.

- **May 15, 2004: 100 publications** were distributed at the Amoskeag Fishways **"Fabulous Fishways Carnival"** in Manchester were the display was located during this time.

- **September 11 & 12, 2004:** Jen Drociak and Art Grindle attended the second annual **Mill City Festival** at Arms Park in Manchester. **123 publications** were distributed at this event.

- **November 13, 2004:** Jen Drociak attended the annual **Rivers & Watershed Conference** in Concord, sponsored by the NHDES and NH Rivers Council. **102 publications were distributed** at this event.

The table below illustrates the Event/Display Locations for 2002, 2003, and 2004. It also details the date of the event, hours in attendance, approximate number of people in attendance, and total number of publications distributed.

Table 2: 2004 Public Events

Event/Display Location	Date Of Event	Hours At Event	# People In Attendance	# Publications Distributed
2002				
NHACC 32nd Annual	11/2/02	2.5	100	27
DES Rivers & Watershed	11/9/02	6	50	26
Springfield College Ecology Class	12/15/02	1.5	25	50
		10	**175**	**103**
2003				
Manchester Chamber of Commerce Visitor Welcome Center		N/A	N/A	50
For Manchester Annual Meeting	2/12/03	4.5	50	6
St. Anselm's College Ecology Class	4/7/03	2	125	218
Manchester Earth Day Forum - PSNH	4/24/03	5	100	204
Amoskeag Fishways Fabulous Fishways Carnival	5/3/03	5	200	121
NH Lakes Association Annual Congress	6/21/03	1		
Mill City Festival - Day 1	9/6/03	5.5	200	189

Mill City Festival - Day 2	9/7/03	8	200	171
Manchester City Library East	10/0/03	N/A		
Amoskeag Fishways	10/0/03	N/A		
UNH Manchester	10/0/03	N/A		
DES Rivers & Watershed	10/0/03	N/A		
Manchester City Library East	11/8/03	5	100	109
	11/14/03-12/12/03			116
		18	**975**	**1134**
2004				
UNH Manchester	1/21/04-3/5/04	N/A	N/A	288
For Manchester Annual Meeting	2/5/04	3	30	65
Manchester Library – West	3/9/04-4/16/04	N/A	N/A	94
Manchester Earth Day Forum	4/23/04	3	50+	21
Household Hazardous Waste Day	5/8/04	5	N/A	83
Amoskeag Fishways Carnival	5/15/04	4	N/A	100
Mill City Festival	9/11 & 9/12/04	18	N/A	123
NH DES Rivers & Watershed Conference	11/13/04	5.5	200	102
		38.5	**280+**	**876**

Mailing List & E-Mail Distribution List

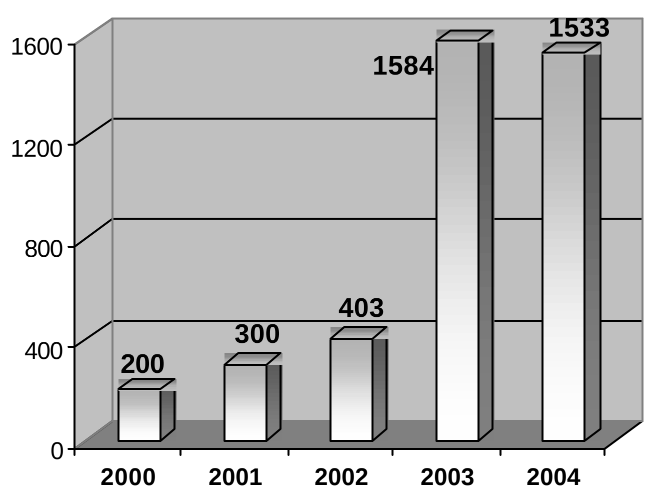
As of December 2004 there were **317 people** on the **UPRP Mailing List.** The mailing list is used primarily for the newsletter.

As of the same time there were **140 people** on the **E-Mail Distribution List**. The e-mail distribution list is used several times a year to distribute the newsletter and notify people of upcoming events, program updates, and success stories.

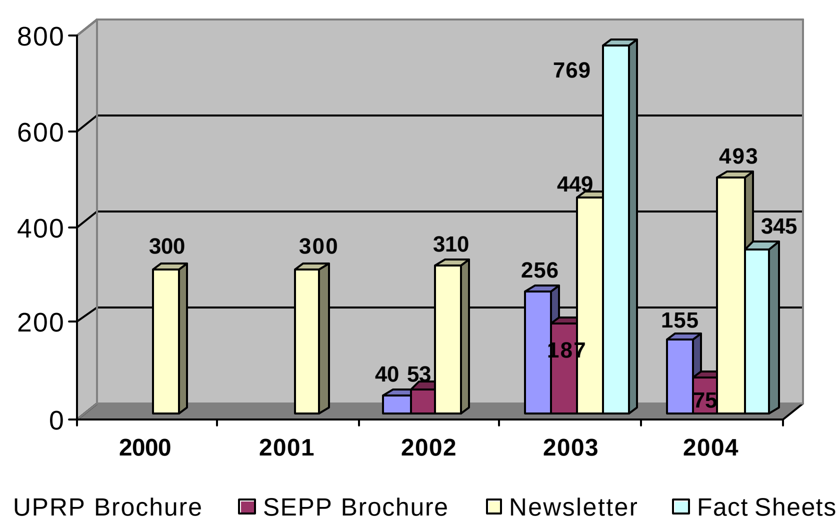
Bi-Annual Newsletter "Pond Possibilities"

Until 2003, the UPRP newsletter "Pond Possibilities" had been distributed once annually. In 2003, the publication became a bi-annual publication and was distributed in both the spring and later summer/early autumn The newsletter is currently distributed to over 400 people citywide in both hard-copy and electronic format and can also be found on the UPRP website.

UPRP TOTAL PUBLICATION DISSEMINATION (2000-2005)



UPRP PUBLICATION DISSEMINATION BY PUBLICATION (2000 - 2004)



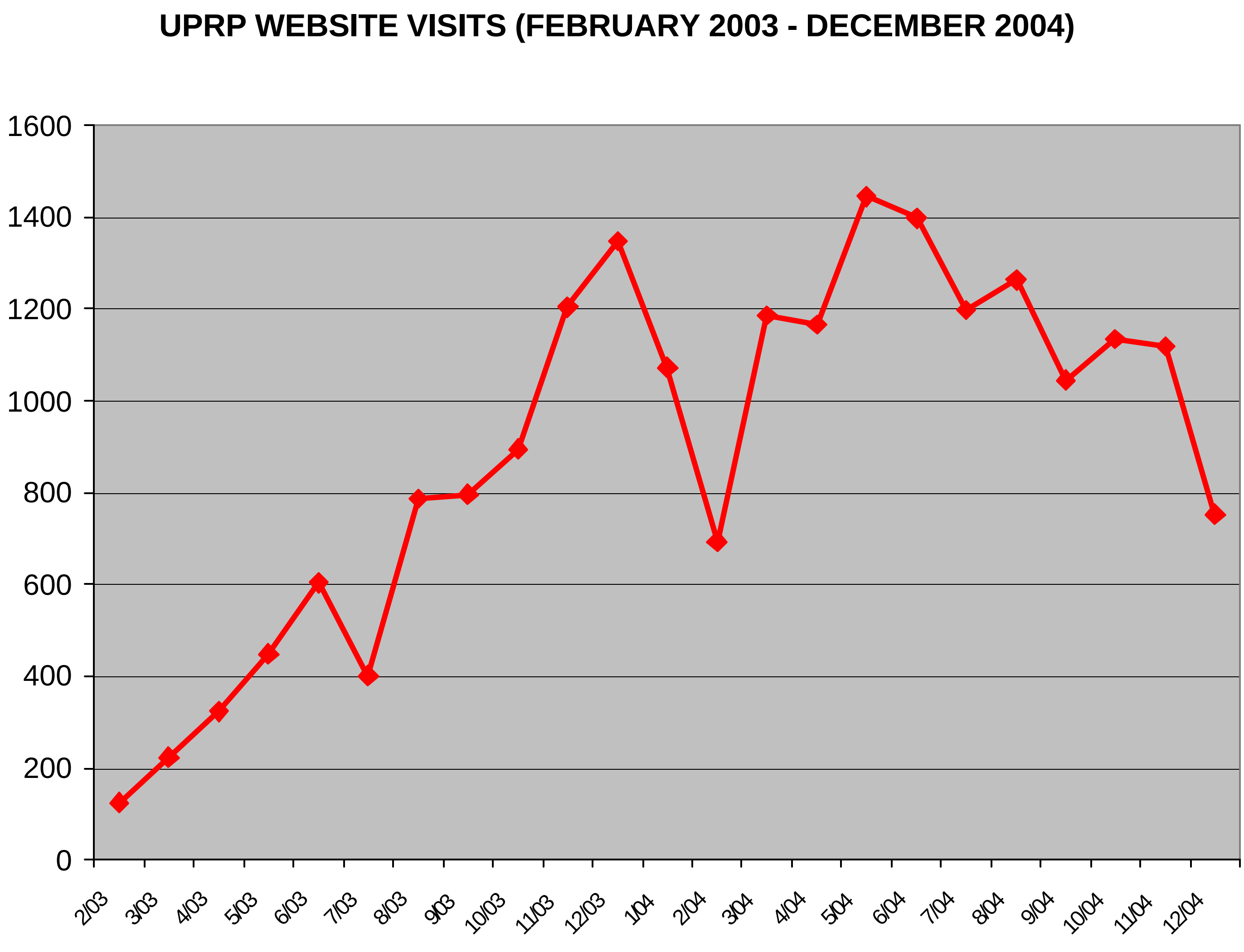
Website

The UPRP website became "live" in February 2003 and contains the following pages: Home, Program Goals & Objectives, Calendar of Events, Publications & Media (containing all UPRP reports, newsletters, fact-sheets, newspaper articles, surveys, and other media), Volunteer Opportunities, Water Quality & Biological Monitoring (including information on water quality monitoring/parameters, fish surveys, vegetation surveys, nonpoint source shoreline surveys, etc), Contact Us, Project Partners & Educational Links, and, a pond-specific page for each of the ponds.

Since February of 2003, we've measured use of the website through its "visits." A visit is defined as the number of visits that include a view of the specified page. Individual visitors are counted each time they come to the website and are counted only once per visit no matter how many page views they look at.

By viewing the graph below, one can see that visits to the UPRP have been somewhat erratic, but generally increasing. In order to increase additional visits we are frequently adding new items of interest to the website and updating old information, therefore keeping it current. The most popular pages are as follows 1) Home (122 views); 2) Water Quality & Biological Monitoring (101 views); 3) Crystal Lake (76 views); 4) Nutts Pond (67 views); 5) Schedule of Events (66 views).

The table below depicts the total visits to the UPRP website per month, since its inception. The website generated an average total of 897 views per month.



SECTION III. SAMPLING PROCEDURES & LABORATORY ANALYSIS COSTS

The UPRP conducted water sampling at Manchester's seven urban ponds once a month from April through October of 2004. This marked the fifth year of baseline water quality data collection at each pond. Water quality monitoring parameters included temperature, dissolved oxygen, pH, acid neutralizing capacity, conductivity, total phosphorus, chlorophyll-*a* abundance, Secchi disk transparency, and turbidity. A brief explanation of each parameter can be found in the Glossary (Appendix B). Table 4 compares the measured parameters in Manchester ponds to a "typical" NH lake.

Due to occasional equipment difficulties and conflicting schedules, data gaps do exist. Given the different circumstances at each pond, the numbers representing the various parameters may not reflect that pond's water quality condition relative to any other of the ponds studied.

The Department of Environmental Services' (DES) Volunteer Lake Assessment Program (VLAP) sampling procedure was used as a template for these sampling sessions. The detailed procedure for collecting water samples is included in Appendix C. VLAP also created annual water quality reports for each pond and can be viewed by visiting http://www.des.state.nh.us/wmb/vlap/. All water sample analyses (except Total Phosphorus) were performed at the DES Limnology Center and Chemistry Laboratory in Concord, NH. The raw water quality data is included in Appendix D.

In 2004, the DES Limnology Center analyzed 337 water samples free of charge. The UPRP thanks DES for these services, which would have totaled **$3,148.00**.

Table 3: DES Limnology Center Sample Analysis Match

Parameter	Number of Samples	Cost Per Sample	Total Cost
Conductivity	117	$6.00	$ 702.00
Chlorophyll-*a*	32	$20.00	$ 640.00
pH	37	$6.00	$ 222.00
ANC	37	$12.00	$ 444.00
Turbidity	114	$10.00	$1,140.00
			$3,148.00

Table 4

Comparison of "Typical" New Hampshire Lake Values[1] to Manchester Pond Values[2]

2003 Sampling Season

Parameter	# of Lake Stations	Typical NH Lake*		Crystal Lake		Dorr s Pond		Maxwell Pond		Nutts Pond		Pine Island Pond		Stevens Pond	
		Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
PH	780	6.5	6.6	6.88	6.91	7.05	7.13	6.23	6.18	6.68	6.68	6.65	6.65	7.01	7.08
Alkalinity	781	6.6	4.9	18.5	17.4	20.3	16.2	6.4	5.1	17.0	17.5	14.6	16.0	29.2	31.6
Total Phosphorus	772		.012	.010	.010	.024	.023	.018	.018	.030	.029	.029	.033	.017	.017
Conductivity	768	59.4	40.0	473	465	759	783	179.5	171.2	786	790	338.5	364.5	1257.8	1229.5
Secchi Disk	663	3.7	3.2	5.0	4.6	1.7	1.7	>1.1	>1.1	2.3	2.3	1.9	1.8	2.9	2.8
Chlorophyll *a*	776	716	4.58	3.14	3.25	18.03	11.71	1.65	1.63	17.13	11.56	2.21	2.63	4.28	3.65

1) "Typical" values are summer epilimnetic values from DES VLAP.
2) Manchester Pond Values are epilimnetic median and mean values.

SECTION IV.

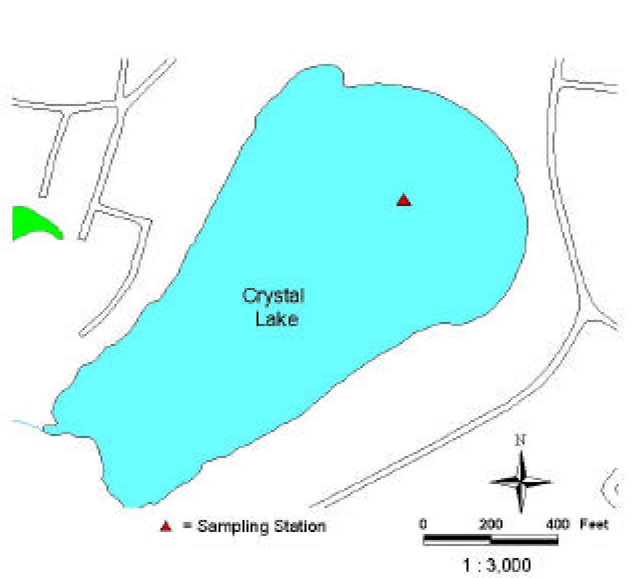
WATER QUALITY MONITORING & STATUS OF MANCHESTER'S URBAN PONDS

CRYSTAL LAKE

Crystal Lake Beach. Photo by Cyndy Carlson

- **Location:** Off Bodwell and Corning Roads in south Manchester
- **Other Names:** Once known as Skenker's Pond, then Mosquito Pond
- **Type of Waterbody:** Natural pond
- **Inlet/Outlet:** No inlet. The outlet, Mosquito Brook, flows into the Great Cohas Swamp/Cohas Brook, then into Pine Island Pond, and eventually empties out into the Merrimack River
- **Watershed Area:** 200.07 acres (81 hectares)
- **Waterbody Size:** 18.67 acres (7.53 hectares)
- **Volume of Water:** 217,000 m3
- **Mean/Average Water Depth:** 9.5 feet (2.9 meters)
- **Maximum Water Depth:** 21 feet (6.4 meters)
- **Shoreline Length:** 3,068 feet (1,100 meters)
- **Elevation:** 206 feet
- **Flushing Rate:** 1.8 times/year
- **Uses:** Swimming, boating, fishing
- **Amenities:** Public swimming beach and bathing facility
- **Local Legend:** "The Hermit of Mosquito Pond", Charles Lambert, who lived self-sufficiently in seclusion at Crystal Lake for over 60 years in the late 1800's and early 1900's.
- **Lake Association:** Crystal Lake Preservation Association (CLPA)

Water Quality



In general, the water quality of Crystal Lake appears to have improved since sampling was first conducted in the early 1980's. The formation of the Crystal Lake Preservation Association (CLPA) may be at least partially responsible for the reduction of phosphorus and algae concentrations. Some parameters, such as conductivity, continue to increase as is common in a continually developing area.

Chlorophyll-*a*

Composite values for chlorophyll-*a* for the upper 3 meters ranged from 1.78 to 7.62 milligrams/cubic meter (mg/m^3), with a median of 3.82 mg/m^3. Chlorophyll-*a* concentrations remain steady and have not significantly changed since monitoring began in 2000.

While algae are naturally present in all lakes/ponds, an excessive or increasing amount of any type is not welcome. In New Hampshire's freshwater lakes/ponds, phosphorus is the limiting nutrient that algae depend upon for growth. Therefore, algal concentrations may increase when there is an increase in nonpoint sources of phosphorus loading from the watershed, or in-lake sources of phosphorus loading (such as phosphorus released from the sediments). It is important to continually educate residents about how activities within the watershed can affect phosphorus loading and lake quality, (i.e. excessive lawn fertilization and unmanaged pet wastes).

Conductivity

Conductivity in the epilimnion (top layers) ranged from 447 to 468 uMhos/cm, with an average of 459 uMhos/cm. The conductivity has increased in the lake with the exception of 2004, since monitoring began in 2000.

Dissolved Oxygen (DO)

The dissolved oxygen concentration was low in the hypolimnion (bottom layer) at the deep spot of the lake during the mid and late summer sampling events. The June sampling event found the water column to be supersaturated. As stratified lakes age, oxygen becomes depleted in the hypolimnion. In addition, depleted oxygen concentration in the hypolimnion of thermally stratified lakes (cold bottom layer, warmer top layer) typically occurs as the summer progresses. Specifically, the loss of oxygen in the hypolimnion results primarily from the process of biological breakdown of organic matter (i.e.; biological organisms use oxygen to break down organic matter), both in the water column and particularly at the bottom of the lake/pond where the water meets the sediment. When oxygen levels are depleted to less than 1 mg/L in the hypolimnion the phosphorus that is normally bound up in the sediment may be re-released into the water column

pH and Acid Neutralizing Capacity (ANC)

The mean pH at the deep spot this season ranged from 6.79 to 7.14, which means that the water column ranges from being slightly acidic to slightly basic.

The Acid Neutralizing Capacity (ANC) ranged from 5.3 to 19.3 mg/L of $CaCO_3$ with an average of 14.4. This is much greater the state mean of 6.7 mg/L. Specifically, this means that the lake/pond has a “low vulnerability” to acidic inputs (such as acid precipitation)

Phosphorus (TP)

The total phosphorus concentration measured in the epilimnion ranged from 0.008 to 0.017 mg/L, with a mean of 0.012 mg/L. The median was 0.009 mg/L.

The current year data for the epilimnion (see Figure 3) show that the total phosphorus concentration increased through the season, peaking in October. The historical data show that the 2004 median epilimnetic total phosphorus concentration is slightly lower than the state median.

The current year data for the hypolimnion show that the total phosphorus concentration remained fairly steady early in the season, then increased by the end of August.

Overall, the statistical analysis of the historical data show that the total phosphorus concentration in the epilimnion and the hypolimnion has not significantly changed since monitoring began in 1993. Specifically, the total phosphorus concentration in the epilimnion and hypolimnion has varied, but has not continually increased or decreased since monitoring began.

Transparency

Secchi disk transparency ranged from 3.0 to 4.9 meters, with a median of 4.0.

The current year data (see Figure 2) show that the in-lake transparency increased from May to June this season, worsened in July then increased through October.

The historical data show that the 2004 mean transparency is greater than the state mean.

Overall, the statistical analysis of the historical data show that the mean annual in-lake transparency has not significantly changed since monitoring began in 1993. Specifically, the in-lake transparency has remained relatively stable and has ranged between approximately 3.0 to 5.0 meters.

Turbidity

Turbidity in Crystal Lake hypolimnion ranged from 1.08 to 4.33 with an average of 2.35 (NTU). Turbidity levels in the epilimnion of Crystal Lake doubled each year from 2000 until 2003 when they were significantly reduced. Average turbidity in the epilimnion doubled from 2003 to 2004.

Table 5[1:] Crystal Lake Water Quality Comparison (1981 – 2004)

		pH	Alkalinity (mg/L)	Total Phosphorus (ug/L)	Conductivity (uhmos/cm)	Secchi Disk (m)	Chlorophyll-a (mg/m3)
7/14/81*		7.3	21.9	0.043	317.0	2.0	-
1985 ** Median		7.2	20.8	0.020	316.0	3.0	22.17
6/30/97[+]		7.1	16.1	0.019	342.0	4.5	-
2000	Mean	6.99	18.1	0.011	418.7	4.3	3.39
	Median	6.94	18.8	0.011	418.0	4.5	2.72
2001	Mean	7.09	17.3	0.012	439.7	3.5	4.75
	Median	7.09	16.0	0.012	444.0	3.5	5.10
2002	Mean	7.07	20.2	0.012	443.8	3.9	2.64
	Median	7.07	17.7	0.013	442.5	4.2	2.64
2003	Mean	6.88	18.5	0.010	473.0	5.0	3.14
	Median	6.91	17.4	0.010	465.0	4.6	3.25
2004	Mean	6.95	14.4	0.012	459.4	3.9	4.62
	Median	6.96	17.1	0.009	458.0	4.0	3.82

1) All values are epilimnetic values, except chlorophyll-*a* which is a composite of measurements taken at several depths.

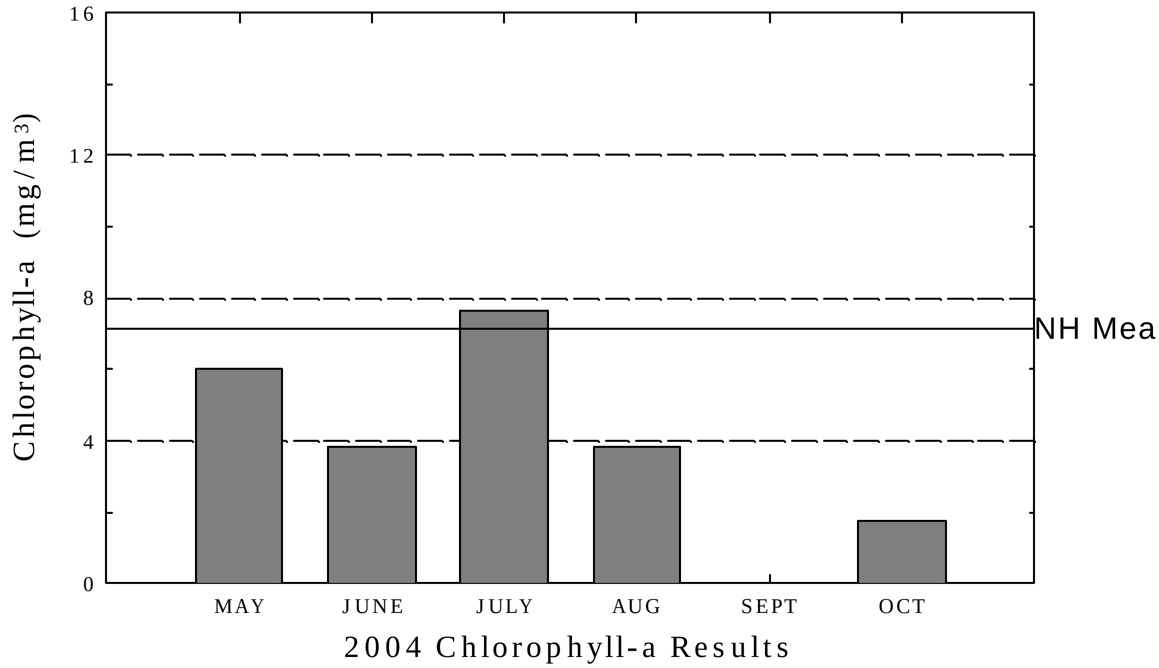
* NH Dept. of Environmental Services. 1981. Trophic Classification of NH Lakes and Ponds.

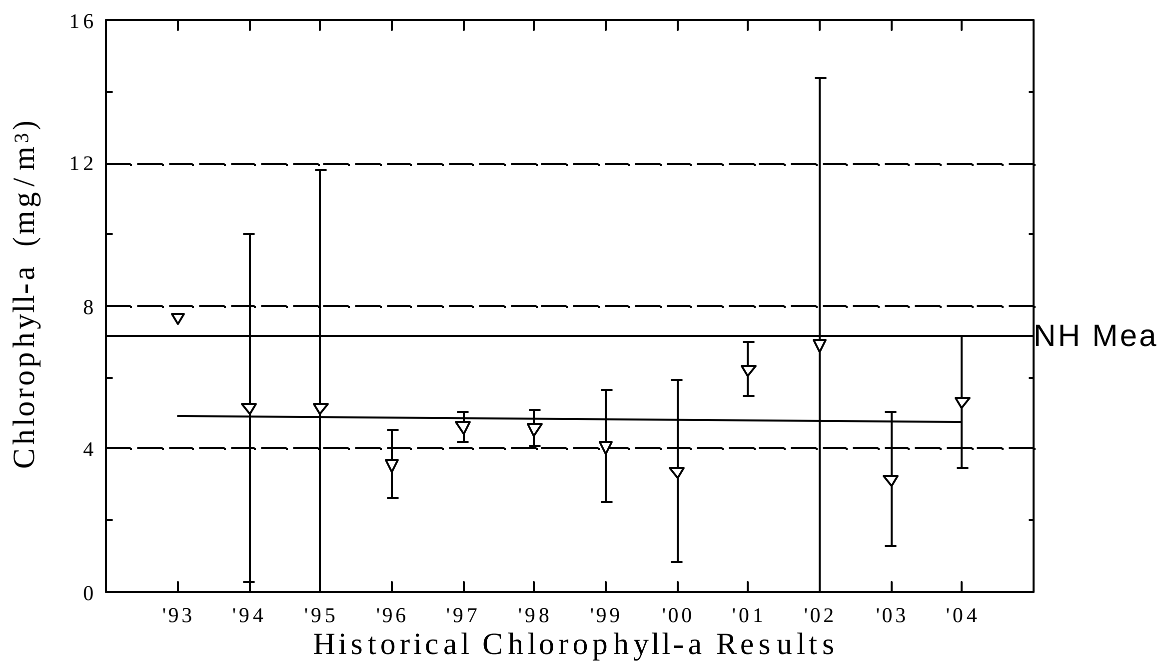
** Estabrook, R., et al. 1985. Urban Lakes Diagnostic/Feasibility Study. Staff Report No. 140. New Hampshire Water Supply and Pollution Control Commission.

\+ NH Dept. of Environmental Services. 1998. Lake Trophic Data.

Crystal Lake, Manchester

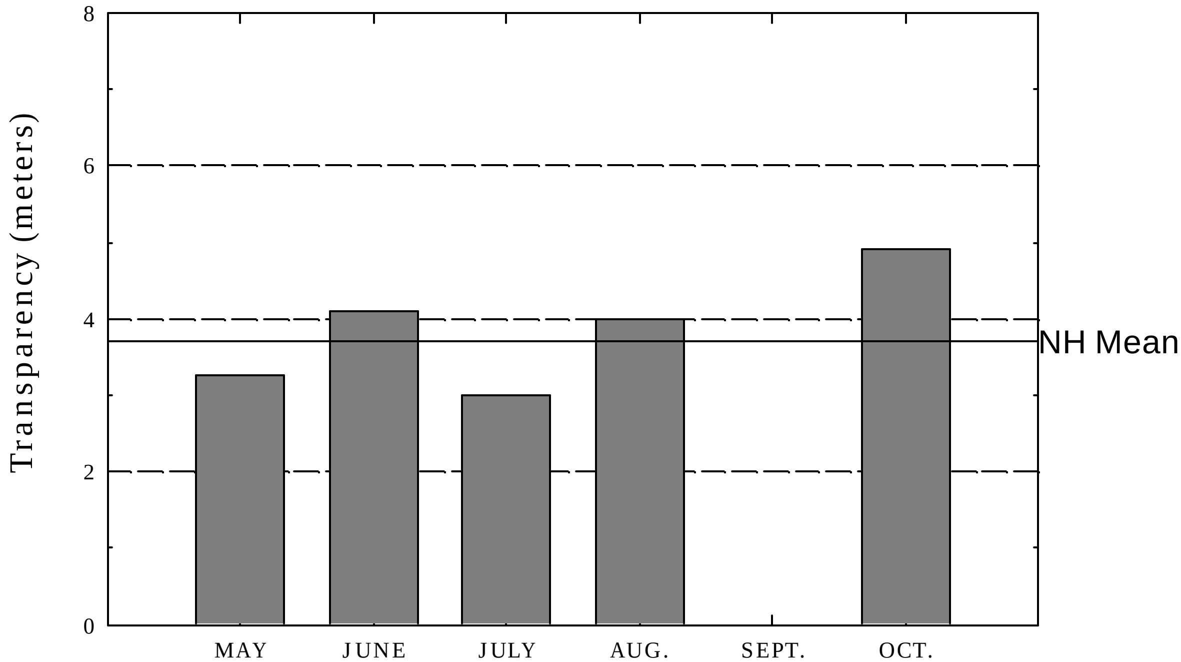
Figure 1. Monthly and Historical Chlorophyll-a Results



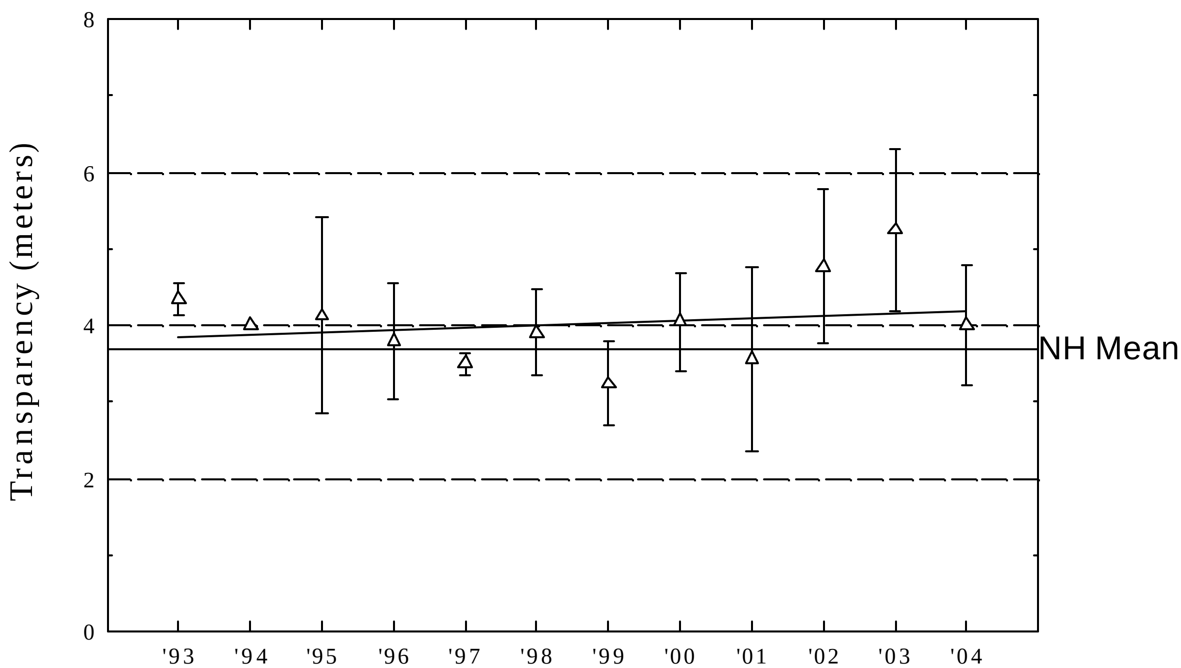


Crystal Lake, Manchester

Figure 2 Monthly and Historical Transparency Results



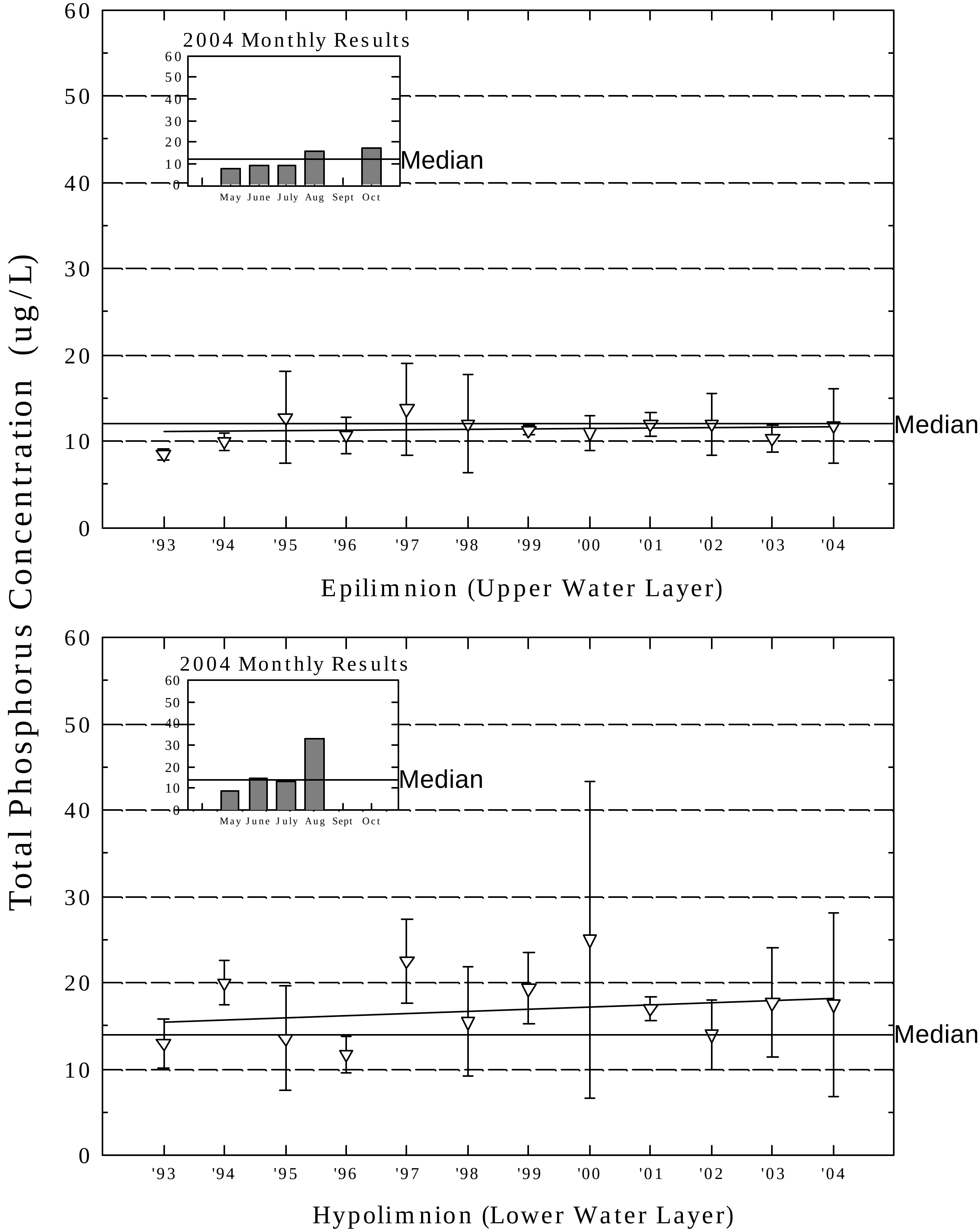
2004 Transparency Results



Historical Transparency Results

Crystal Lake, Manchester

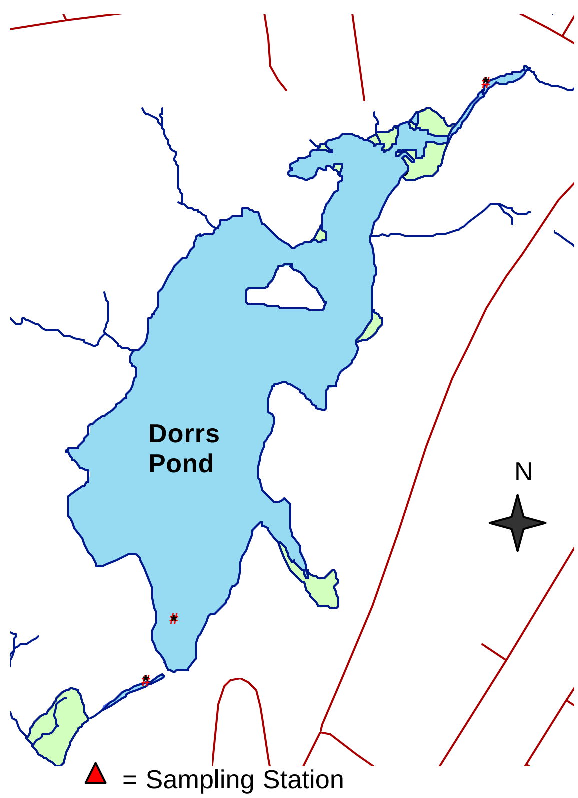
Figure 3 Monthly and Historical Total Phosphorus Data.



DORRS POND

Dorrs Pond. Photo by Cyndy Carlson

- **Namesake:** Named after George Horace Dorr who purchased the property in the 1800's
- **Location:** At Livingston Park, on Daniel Webster Highway in north Manchester
- **Type of Waterbody:** Artificial pond impounded by dam on Ray Brook outlet in 1862
- **Inlet/Outlet:** Ray Brook, beginning at Goldfish Pond in Hooksett, and emptying into the Merrimack River in north Manchester
- **Watershed Area:** 1,472 acres (596 hectares)
- **Waterbody Size:** 17.6 acres (7.12 hectares)
- **Volume of Water:** 92,000 m3
- **Mean/Average Water Depth:** 4.26 feet (1.3 meters)
- **Maximum Water Depth:** 9.51 feet (2.9 meters)
- **Shoreline Length:** 5,248 feet (1,600 meters)
- **Elevation:** 270 feet
- **Percent of Watershed Impounded:** 0.5%
- **Flushing Rate:** 31.2 times/year
- **Uses:** Paddling, fishing, ice-skating, hiking and biking
- **Amenities:** Livingston Park, playground, athletic fields, swimming pool, trail system
- **Lake Association:** Dorrs Pond Preservation Society (DPPS)



Water Quality

The overall water quality of Dorrs Pond has not significantly changed over the last twenty years, though it is slightly more degraded now. Conductivity has increased greatly, but phosphorus and chlorophyll-*a* levels seem to have decreased. The approximately 134 acres of city-owned forested woodland which surrounds the pond has prevented pondside development, thus providing the pond a reprieve from receiving any more direct urban runoff than it historically has.

Chlorophyll-*a*

Composite values for chlorophyll-*a* for the upper 1.5 meters ranged from 8.75 to 26.14 mg/m^3, with a mean of 15.09 mg/m^3. DES considers concentrations greater than 15 mg/m^3 to be a nuisance amount that is indicative of an algal bloom. Composite samples are derived from combining water samples from each meter of the water column from the midpoint of the metalimnion (middle layer) to the surface.

The current year data (see Figure 5) show that the chlorophyll-a concentration was relatively low at the start and end of the season, and peaked in July.

The historical data show that the 2004 chlorophyll-a mean is more than twice the state mean.

Overall, visual inspection of the historical data shows consistent variation in-lake chlorophyll-a, meaning that the concentration has fluctuated since monitoring originally began in 1996.

Conductivity

Conductivity in the epilimnion ranged from 533 to 757 uMhos/cm, with a mean of 644 uMhos/cm. When the pond was stratified, the hypolimnion conductivity averaged 652.5 uMhos/cm. Conductivity has steadily dropped for the past two years. As expected, the two major inlets also were highly conductive, averaging 850 and 807 uMhos/cm each. Though these represent decreases from previous years, these are still very high conductivity levels, most likely caused by the large amount of urban runoff that this location receives. Mean conductivity levels have risen significantly since 1985.

Dissolved Oxygen (DO)

Hypolimnion dissolved oxygen readings varied greatly from month to month at Dorrs Pond. This may be due to the shallow area in which readings were taken. The sampling station is relatively close to the dam/outlet which creates a current in this area. Factors influencing pond flow, such as precipitation, may also influence dissolved oxygen concentration in this particular area.

The dissolved oxygen concentration was consistently low in the hypolimnion at the deep spot of the pond, but not depleted. The season's lowest recorded dissolved oxygen saturation was 40%. As stratified lakes/ponds age, oxygen becomes depleted in the hypolimnion (the lower layer) by the process of decomposition. Specifically, the loss of oxygen in the hypolimnion results primarily from the process of biological breakdown of organic matter (i.e.; biological organisms use oxygen to break down organic matter), both in the water column and particularly at the bottom of the lake/pond where the water meets the sediment. When oxygen levels are depleted to less than 1 mg/L in the hypolimnion, the phosphorus that is normally bound up in the sediment may be re-released into the water column.

pH and Acid Neutralizing Capacity (ANC)

The pH of Dorrs Pond ranged from 6.72 to 7.47, with an average of 6.97. pH values in the 1985 DES study were not significantly different than those taken from 2000 through 2004. The 1985 median was 7.0. Alkalinity, or Acid Neutralizing Capacity (ANC) ranged from 20.6 to 28.4 mg of CaCO/L, peaking in August, with an average of 24.3 mg/L in 2004. This is much greater than the state mean of 6.7 mg/L. Specifically, this means that the pond is "not vulnerable" to acidic inputs (such as acid precipitation).

Total Phosphorus (TP)

The total phosphorus concentration (TP) measured in the epilimnion of Dorrs Pond varied from .020 to .036 mg/L, with a mean of .028 mg/L. This is an increase from TP levels measured in 2003. When the pond was stratified, TP in the lower level or hypolimnion reached 0.042 mg/L. Two of the pond's main inlets are still significant sources of phosphorus input, even with apparent reduction from last year at Lessard's Brook. Lessard's Brook averaged 0.026 mg/L of TP and Inlet 2 East averaged 0.038 mg/L of TP.

The current year data (Figure 7) for the epilimnion show that the total phosphorus concentration remained relatively steady with a peak in August. The total phosphorus concentration on each sampling event was greater than the state median.

Overall, visual inspection of the historical data trend line for the epilimnion shows relatively stable total phosphorus trend since monitoring began in 1996.

Transparency

Secchi disk transparency ranged from 1.1 to 2.5 meters, with a median of 1.6 meters. The minimum transparency was recorded in July. Water clarity and chlorophyll-*a* concentrations seem to be somewhat related since water clarity and chlorophyll *a* both peaked in July.

Overall, visual inspection of the historical data trend line (see Figure 6) shows a stable trend for in-lake transparency, meaning that the transparency has not varied greatly since monitoring began in 1996.

Turbidity

Turbidity of epilimnion samples ranged from 2.90 to 6.64 (NTU), with an average of 4.61 (NTU) in 2004. High turbidity is most likely caused by a large volume of urban runoff to this location. Turbidity measurements were not taken at Dorrs Pond during the 1985 DES Diagnostic/Feasibility Study.

Table 6[1]: Dorrs Pond Water Quality Comparison (1981 – 2004)

		pH	**Alkalinity** (mg/L)	**Total Phosphorus** (ug/L)	**Conductivity** (umhos/cm)	**Secchi Disk** (m)	**Chlorophyll-*a*** (mg/m3)
7/14/81*		6.80	13.9	0.060	201	1.3	-
1985 ** Median		7.00	15.4	0.042	258	1.6	38.84
7/17/97+		7.10	22.2	0.031	469	1.3	-
2000	Mean	7.08	16.2	0.045	408	1.1	30.84
	Median	7.08	-	-	-	1.0	-
2001	Mean	7.15	21.7	0.024	831.3	1.3	14.75
	Median	7.09	21.9	0.024	851.0	1.1	9.74
2002	Mean	7.07	26.5	0.021	882.6	2.0	8.40
	Median	7.07	26.5	0.021	899.0	2.0	8.72
2003	Mean	7.05	20.3	0.024	759.0	1.7	18.03
	Median	7.13	16.2	0.023	783.0	1.7	11.71
2004	Mean	6.97	24.3	0.028	644.0	1.7	15.09
	Median	6.87	23.8	0.028	648.0	1.6	12.74

1) All values are epilimnetic, except chlorophyll-*a* which is a composite.

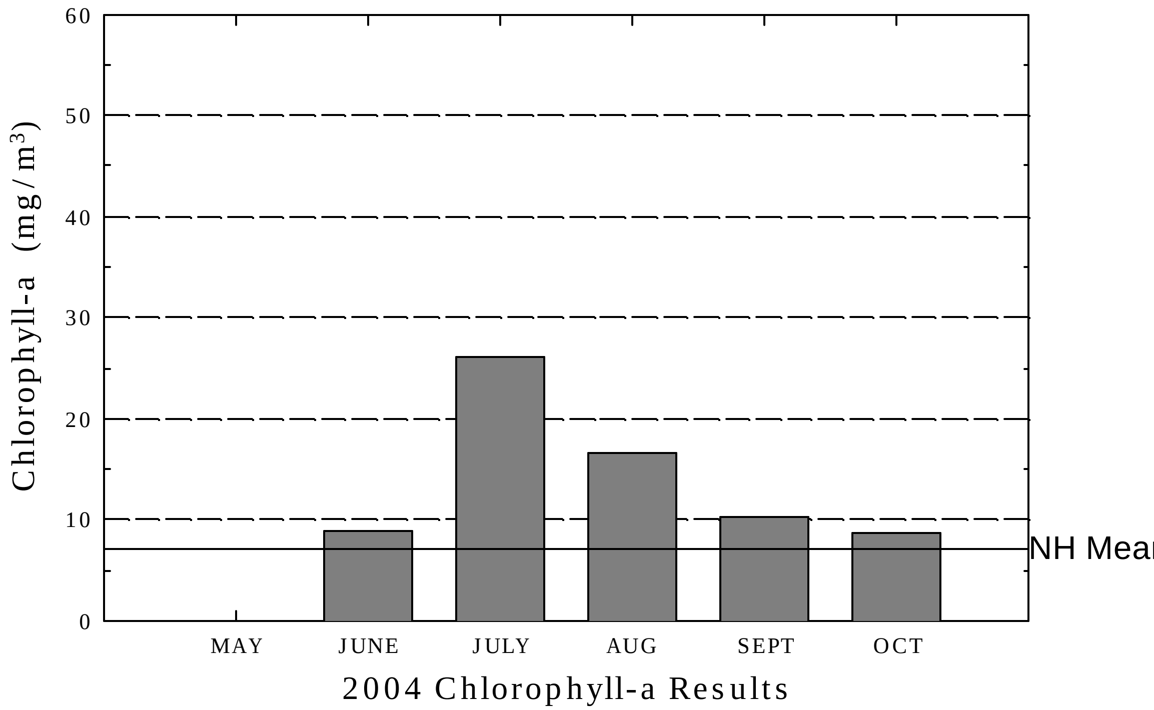
* NH Dept. of Environmental Services. 1981. Trophic Classification of NH Lakes and Ponds.

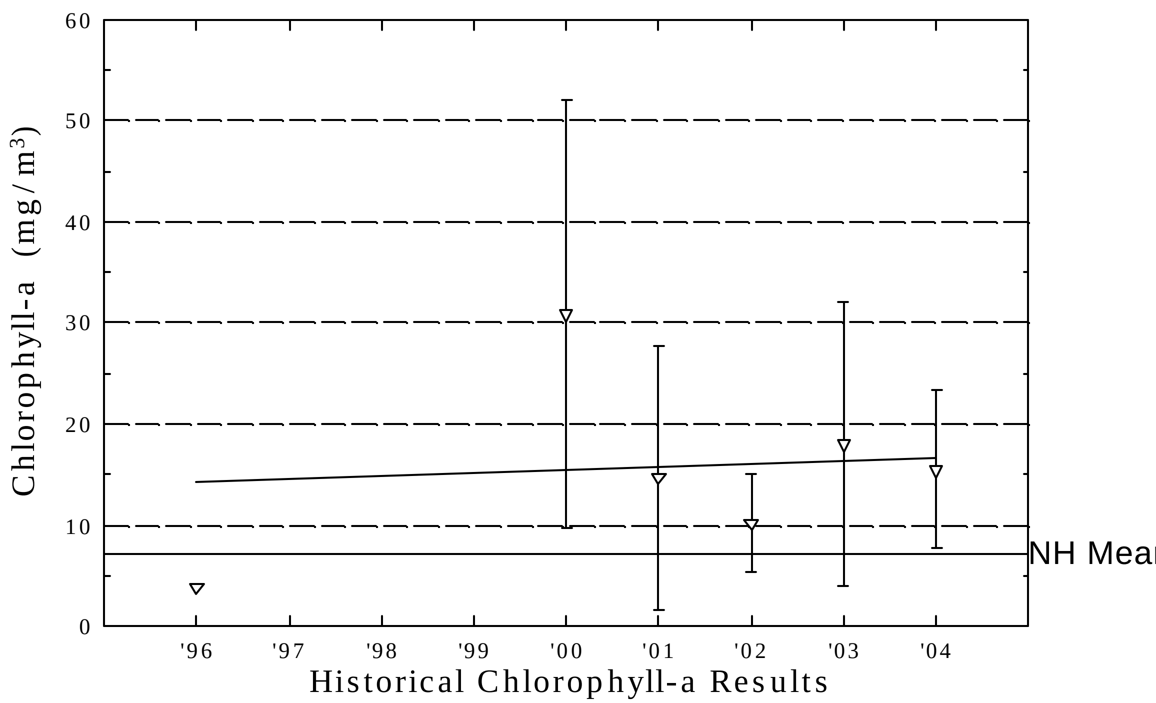
** Estabrook, R., et.al. 1985. Urban Lakes Diagnostic/Feasibility Study. Staff Report No. 140. New Hampshire Water Supply and Pollution Control Commission.

+ NH Dept. Of Environmental Services. 1998. Lake Trophic Data.

Dorrs Pond, Manchester

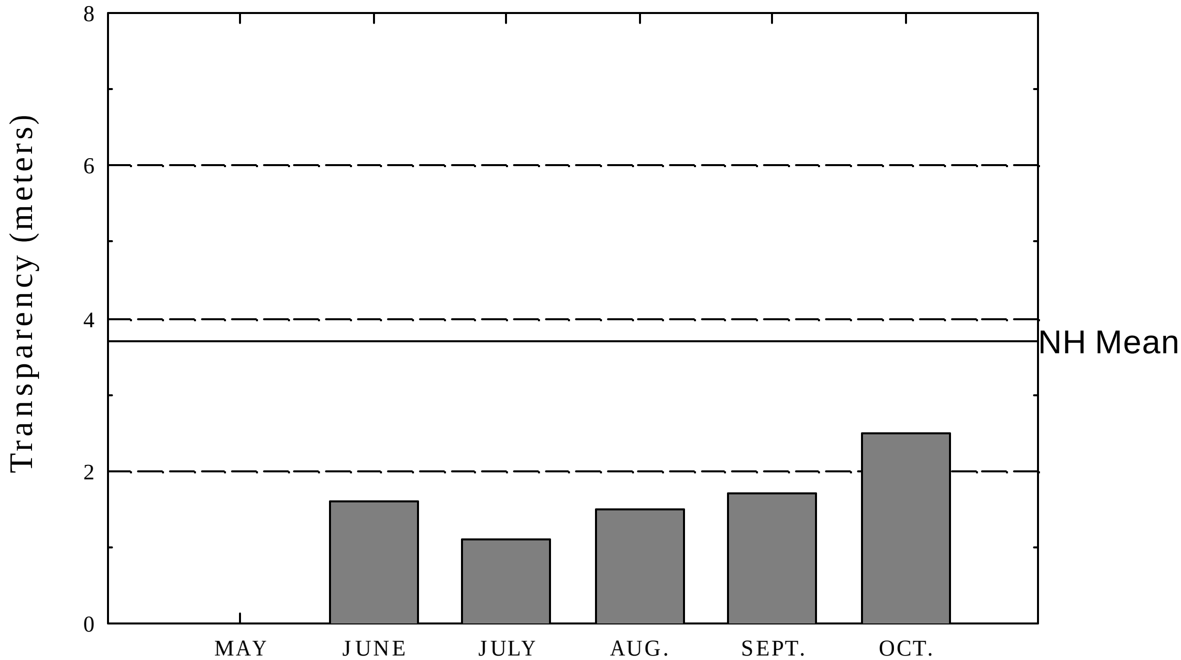
Figure 4 Monthly and Historical Chlorophyll-a Results



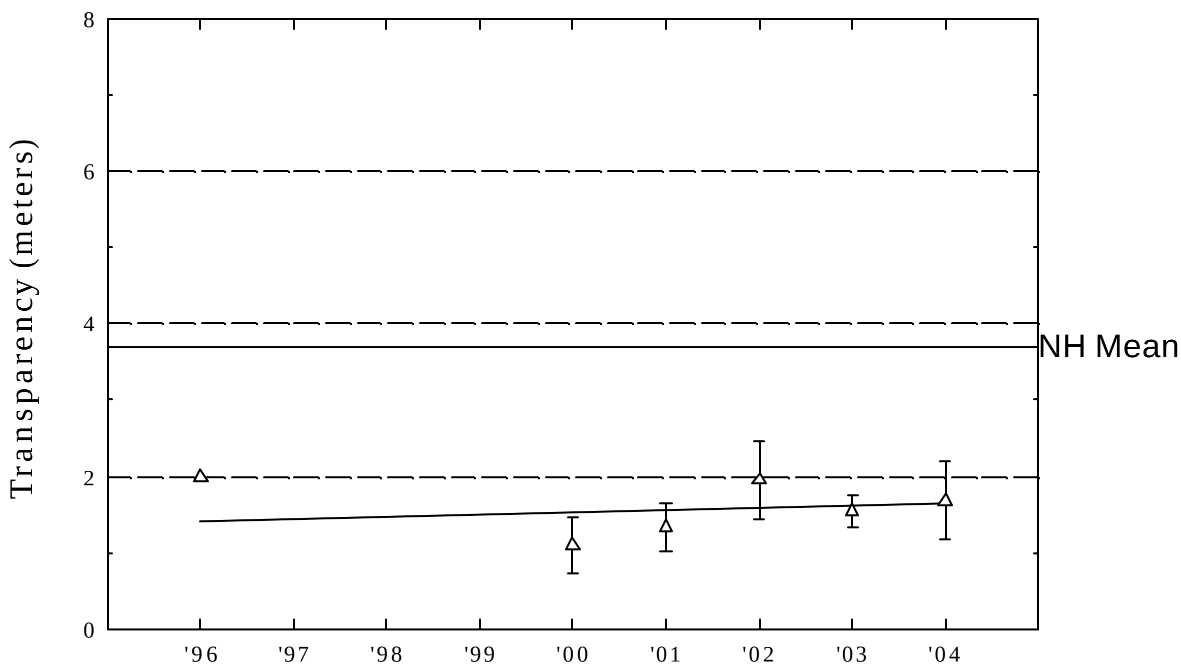


Dorrs Pond, Manchester

Figure 5. Monthly and Historical Transparency Results



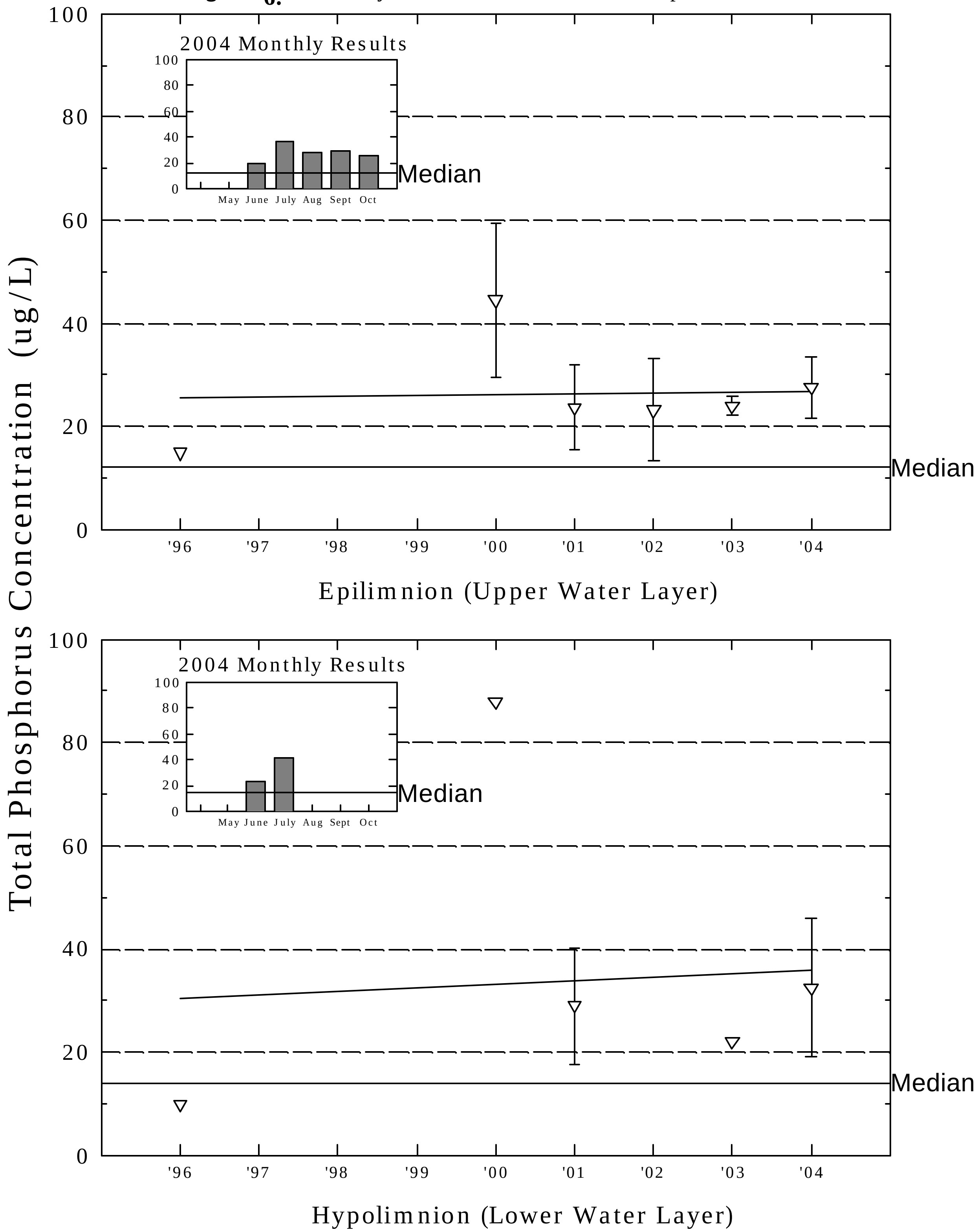
2004 Transparency Results



Historical Transparency Results

Dorrs Pond, Manchester

Figure 6. Monthly and Historical Total Phosphorus Data.



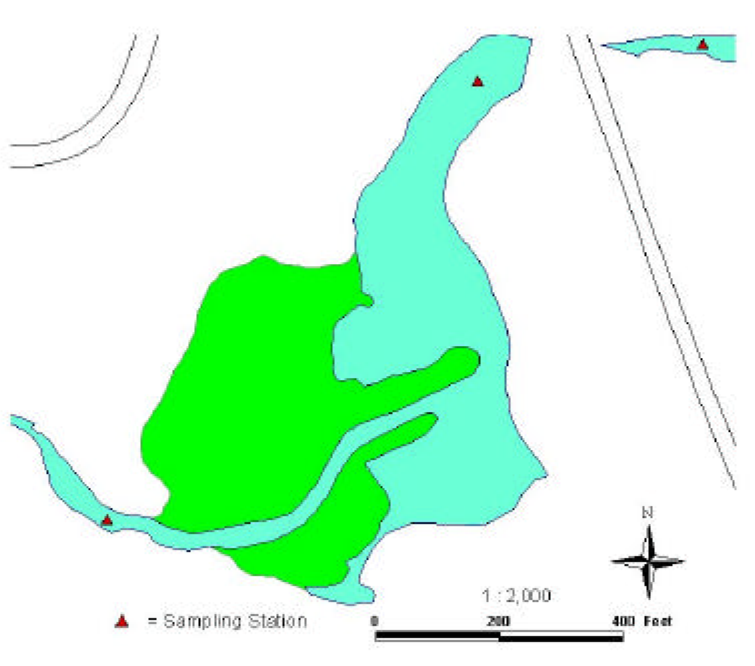
MAXWELL POND

- **Namesake:** Named after A.H. Maxwell, who owned Manchester Coal & Ice Company
- **Location:** Front Street at the intersection of Dunbarton Road, in northwest Manchester
- **Type of Waterbody:** Artificial Pond created by impoundment on Black Brook in 1900
- **Inlet/Outlet:** Black Brook, beginning in Dunbarton and emptying into the Merrimack River under I293 in northwest Manchester
- **Watershed Area:** 1,502 acres (608 hectares)
- **Waterbody Size:** 5.5 acres (2.22 hectares)
- **Volume of Water:** 12,900 m3
- **Mean Water Depth:** 4 feet (1.2 meters)
- **Maximum Water Depth:** 13.12 feet (4.0 meters)
- **Shoreline Length:** 10,168 feet (3,100 meters)
- **Elevation:** 235 feet
- **Flushing Rate:** 217 times/year
- **Uses:** Fishing, passive recreation, environmental education
- **Amenities:** Blodget Park playground

Maxwell Pond. Photo by Jen Drociak

Water Quality

The water quality of Maxwell Pond is better than any other Manchester Pond. Maxwell Pond has a very high turnover rate and relatively little urban development in the watershed. Its stream-like characteristics allow most nutrients to wash downstream. However, rapid sedimentation (due to the dam) and vegetation growth is occurring in some parts of the pond.



Chlorophyll-*a*

Chlorophyll-*a* concentrations were low, ranging from 1.40 to 3.04 mg/m^3, and averaging 2.30 mg/m^3. These low readings are most likely due to the pond's high flushing rate.
The current year data (see Figure 9) show that the chlorophyll-*a* concentration fluctuated only slightly throughout the season. The historical data show that the 2004 chlorophyll-*a* mean is less than the state mean.

Overall, visual inspection of the historical data trend line shows a stable in-lake chlorophyll *a* trend, meaning that the concentration has remained approximately the same since monitoring began in 2000.

Conductivity

Conductivity of Maxwell Pond ranged from 112.7 to 175.8 uMhos/cm, with an average of 151.0 uMhos/cm. DES 1981 data shows conductivity at 56.0 uMhos/cm. Inlet samples ranged from 112.1 to 177.0 uMhos/cm and averaged 151.2 uMhos/cm in 2004.

The conductivity in the pond and in the inlet is relatively high. Typically conductivity levels greater than 100 uMhos/cm indicate the influence of human activities on surface water quality. These activities include septic systems that fail and leak leachate into the groundwater (and eventually into the tributaries and the lake/pond), agricultural runoff, and road runoff (which contains road salt during the spring snow melt). New development in the watershed can alter runoff patterns and expose new soil and bedrock areas, which could contribute to increasing conductivity. In addition, natural sources such as iron deposits in bedrock, can influence conductivity.

Dissolved Oxygen (DO)

Dissolved oxygen levels are consistently high in relation to other Manchester ponds due to the stream-like characteristics of Maxwell Pond. The lowest dissolved oxygen saturation recorded at Maxwell Pond was 59.0% at the pond's deepest point. DO levels in 2004 were very similar to those found in prior years.

pH and Acid Neutralizing Capacity (ANC)

The pH at the deep spot this season ranged from 6.05 to 6.96, which means that the water is slightly acidic. pH readings at Maxwell Pond have been similar throughout the past five years of sampling. The values are slightly low for NH freshwater ecosystems, but still well within the range for supporting aquatic life. pH readings by NH DES in 1981 were similar at 6.4. ANC was also consistently lower than other Manchester ponds, ranging from 3.3 to 7.9 mg of CaCO/L, with an average of 5.5 mg/L. In 1981, NH DES found ANC to be 6.4 mg/L. Maxwell is therefore less able to buffer acidic inputs, which may help explain the low pH readings. This is slightly lower than the state mean of 6.7 mg/L. Specifically, this means that the lake/pond is "moderately vulnerable" to acidic inputs (such as acid precipitation).

Total Phosphorus (TP)

Due to the fact that the deepest spot in Maxwell Pond is 1.1 meters, there was no thermal stratification, so only "surface grab" samples were necessary for in-pond sampling. Total phosphorus concentrations ranged from 0.013 to 0.050 mg/L, with an average of 0.022 mg/L. Due to the high turnover of pond volume and shallowness here, inlet samples are especially important. TP concentrations in the inlet samples (Black Brook) peaked at 0.051 mg/L and averaged 0.021 mg/L.

The current year data (see Figure 11) show that the total phosphorus concentration increased overall from May to June, then leveled off. The 0.05 mg/L reading, which occurred in September, seems to be an anomaly. The total phosphorus concentration was greater than the state median on each sampling event.

The historical data show that the 2004 mean epilimnetic total phosphorus concentration is greater than the state median.

Overall, visual inspection of the historical data trend line shows a slightly increasing phosphorus trend.

Transparency

As the bottom could clearly be seen at 1.1 meters, Secchi disk transparency was greater than 1.1 meters and could not be measured more accurately due to lack of depth. The transparency was greater than the pond depth, i.e. one can see the pond bottom. The Secchi-disk was visible on the bottom of the pond on each sampling event.

Since the transparency can not be accurately measured due to the shallowness of the pond, it is impossible to determine a trend.

Turbidity

Turbidity in Maxwell Pond ranged from 1.07 to 3.21 (NTU) and averaged 2.12 (NTU). NH DES 1981 turbidity readings were a bit higher at 4.3 (NTU). The 2004 readings reinforce a stable data trend for turbidity.

Maxwell Pond water quality has remained consistent since 2000, with the exception of conductivity which has increased. Five years of data, however, do not accurately represent a trend. Natural fluctuations, upstream disturbances and discharges, and precipitation variations could all be singled out as reasons for water quality fluctuations.

Table 7[1]: Maxwell Pond Water Quality Comparison (1981-2004)

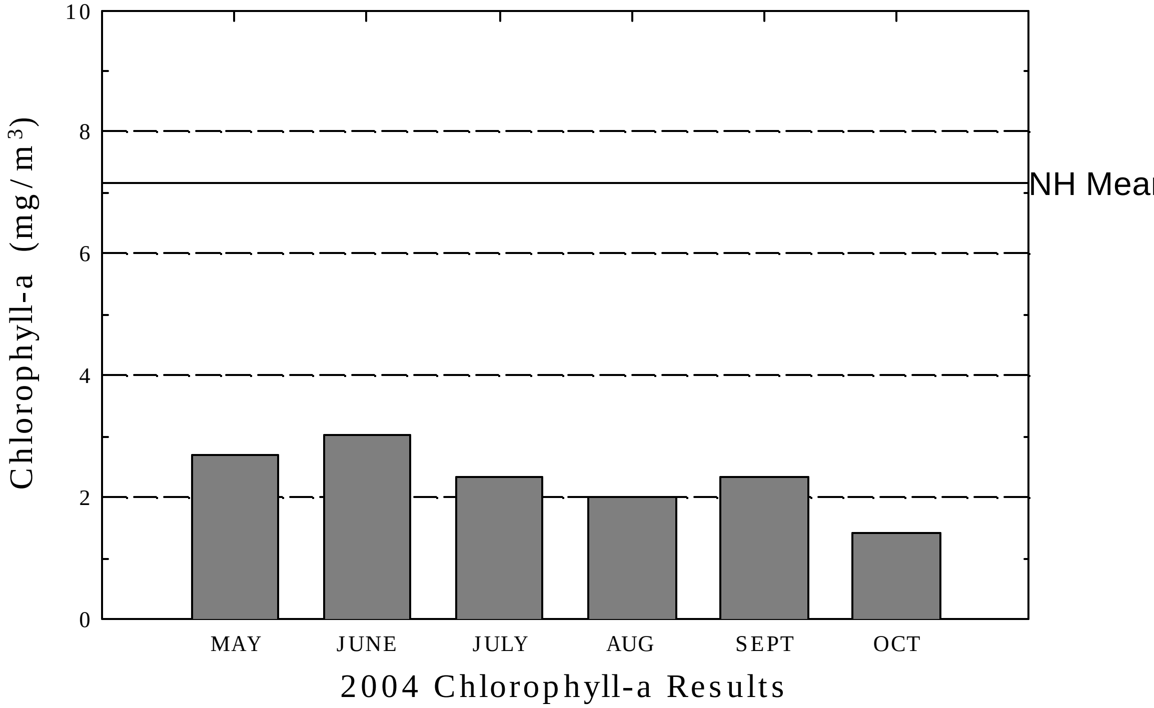
		pH	**Alkalinity** (mg/L)	**Total Phosphorus** (mg/L)	**Conductivity** (umhos/cm)	**Secchi Disk** (m)	**Chlorophyll-*a*** (mg/m3)
1981*		6.4	7.00	0.018	56.00	>1.2	-
2000	Mean	6.54	6.80	0.014	121.8	>1.1	1.55
	Median	6.55	6.90	0.014	127.3		1.07
2001	Mean	6.63	9.80	0.018	154.6	>1.1	3.17
	Median	6.62	9.60	0.018	148.5		4.01
2002	Mean	6.50	6.74	0.015	201.4	>1.1	1.68
	Median	6.52	3.60	0.016	147.8		1.68
2003	Mean	6.23	6.40	0.017	179.5	>1.1	1.65
	Median	6.18	5.05	0.018	171.2		1.63
2004	Mean	6.38	5.47	0.022	151.0	>1.1	2.30
	Median	6.30	5.05	0.016	155.5		2.34

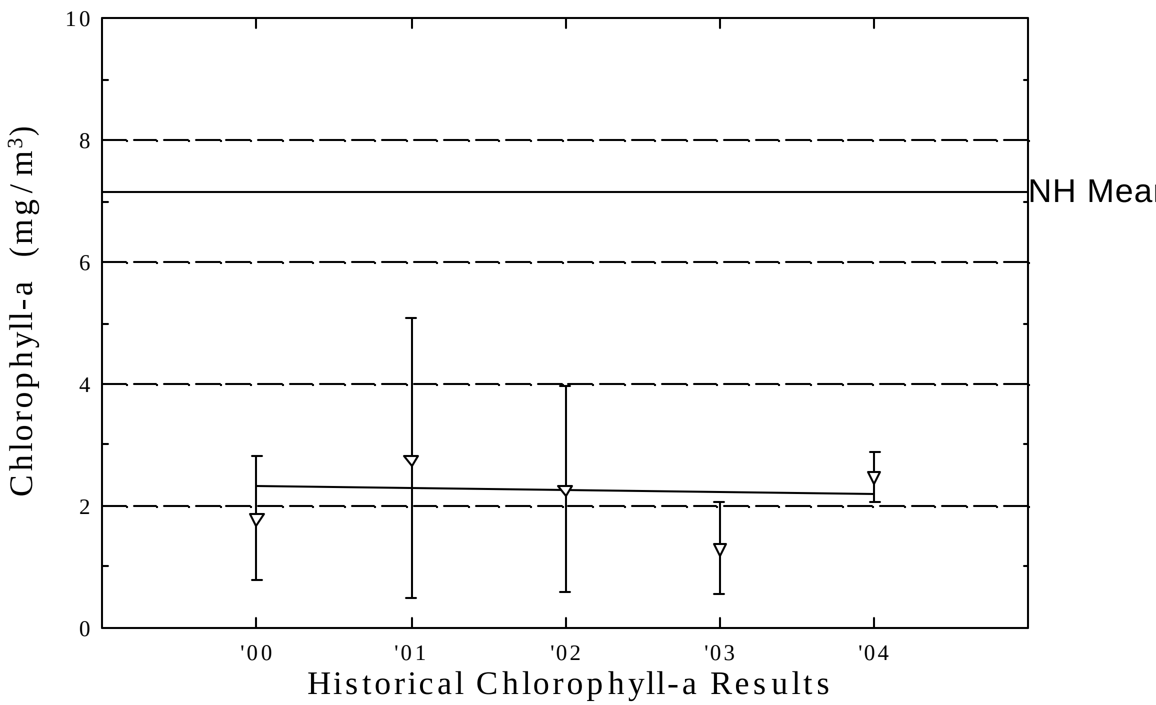
1) All values are epilimnetic.

* NH Dept. of Environmental Services. 1981. Trophic Classification of NH Lakes and Ponds.

Maxwell Pond, Manchester

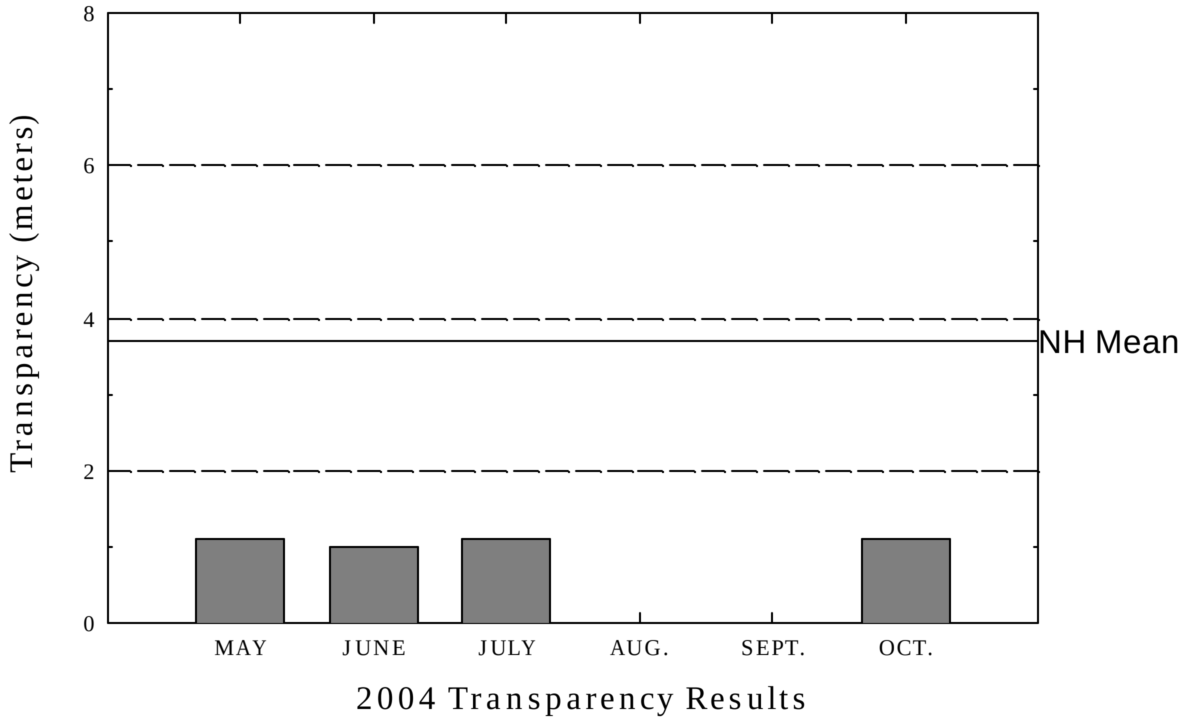
Figure 7. Monthly and Historical Chlorophyll-a Results

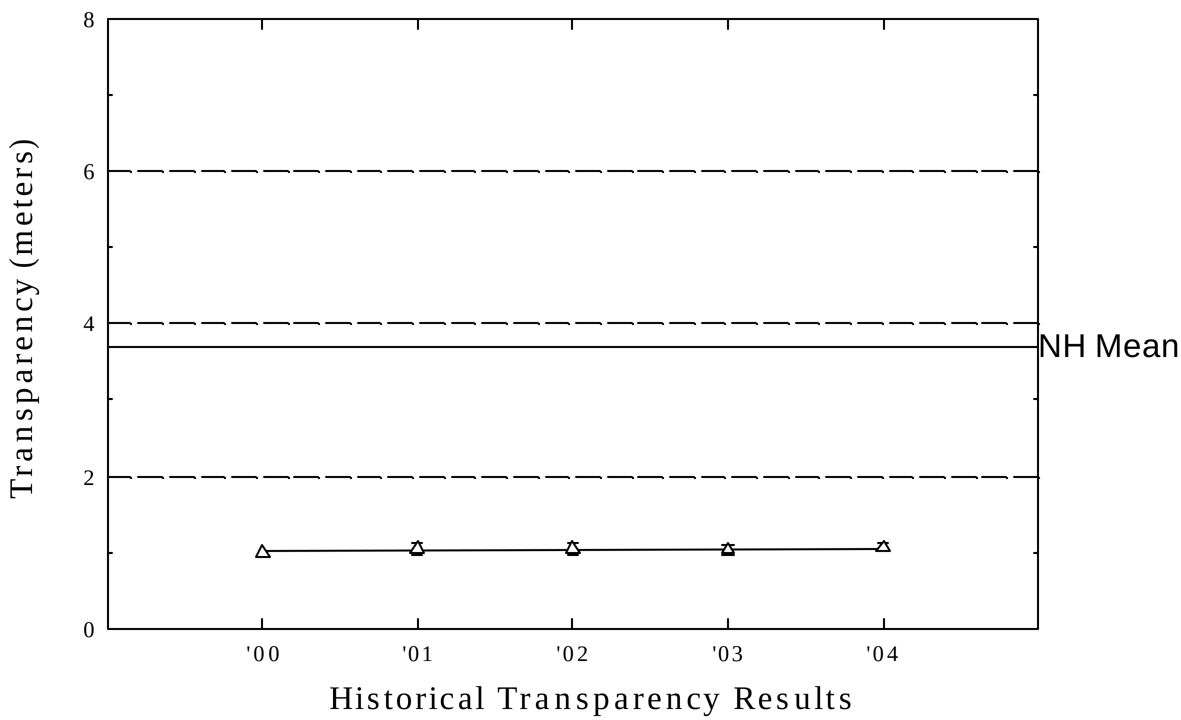




Maxwell Pond, Manchester

Figure 8. Monthly and Historical Transparency Results





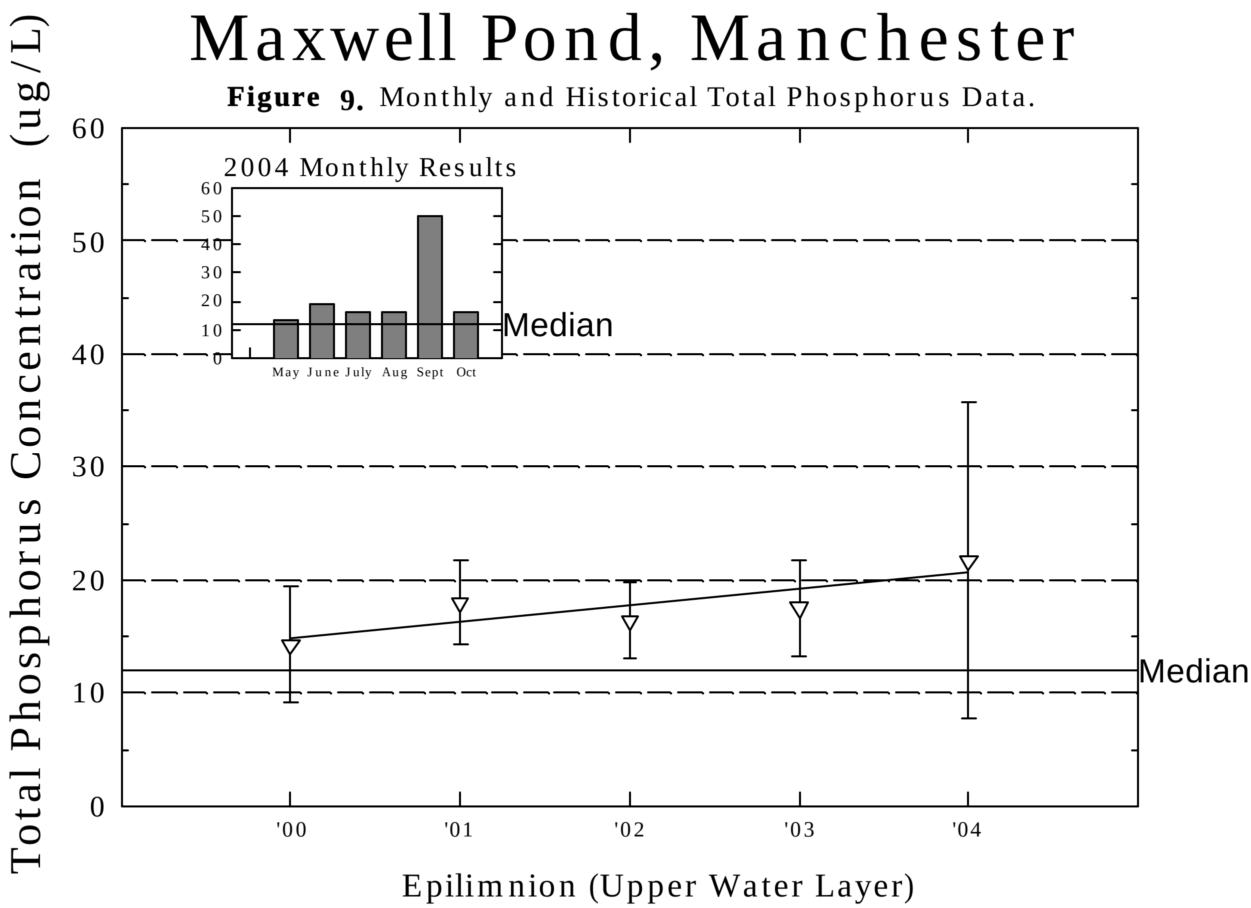


Figure 9. Monthly and Historical Total Phosphorus Data.

MCQUESTEN POND

Pond Location and Description

McQuesten Pond is located behind the businesses of Second Street to the east and Wolfe Park to the north. It is used for birdwatching and wetlands education. At less than two feet deep, it is barely able to be classified as a pond at all. The McQuesten wetland area is very rich in life, featuring more than twenty bird species.

McQuesten Pond. Photo by Jen Drociak

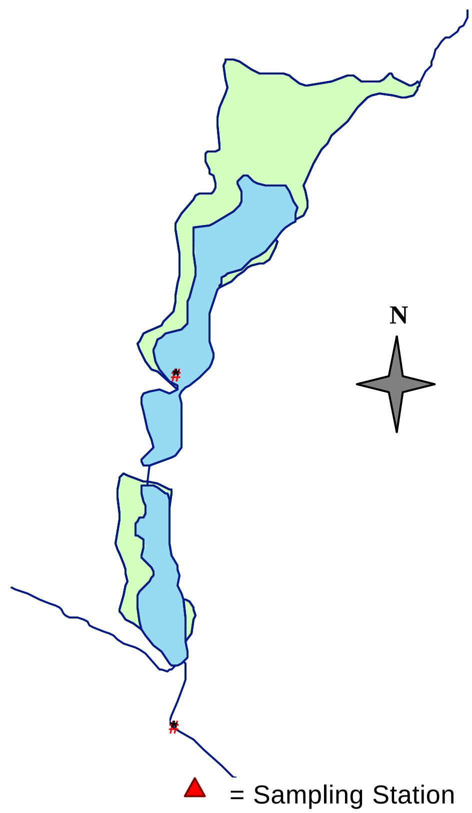
Water Quality

McQuesten Pond is little more than a flooded wetland. It's high biologically productivity is partly due to its shallow depth and rich sources of organic debris. Therefore, it is inappropriate to compare this water body to other typical New Hampshire lakes and ponds. The water quality at McQuesten Pond remains consistent after five years of data collection.

McQuesten Pond is less than 18 inches deep in any spot, therefore in-pond sampling was atypical here. The flushing rate of the ponded area of the McQuesten wetland complex is high. Outlet sample results were very similar to in-pond sample results.

Chlorophyll-a

Overall, visual inspection of the historical data trend line (see Figure 13) shows a decreasing in-lake chlorophyll-*a* trend, meaning that the concentration has improved since monitoring began in 2000. However, please keep in mind that this trend is based on an extremely limited data set, and may not be representative of actual conditions.



Conductivity

In-pond conductivity was high, averaging 642.0 uMhos/cm. Outlet conductivity levels were similar at 621.8 uMhos/cm.

The conductivity continues to be very high in this pond. Typically, sources of elevated conductivity are due to human activity. These activities include road and parking lot runoff (which contains road salt during the spring snow melt) and organic debris.

Dissolved Oxygen (DO)

Dissolved oxygen levels in McQuesten Pond indicate a very highly productive system. When DO levels could be discerned, they showed the pond to be supersaturated during the majority of sampling events.

pH and Acid Neutralizing Capacity (ANC)

McQuesten Pond had an average pH of 6.64. Acid neutralizing capacity was relatively high at 31.4 mg/L of CaCO.

The pH this season ranged from 6.46 to 6.85. Unlike previous seasons, the pH remained slightly acidic all season.

The Acid Neutralizing Capacity (ANC) of the pond continue to remain high, with the mean (31.4 mg/L as $CaCO_3$) being much greater than the state mean. This indicates that the pond is "not vulnerable" to acidic inputs (such as acid precipitation) and has a greater ability than most lakes and ponds in the state to buffer against acidic inputs. While this may seem like a positive condition in the pond, the high ANC is likely due to the degraded conditions of the pond. We suspect that there is a high concentration of pollutants and ions (such as salts) that account for the elevated ANC in the pond.

Phosphorus (TP)

Total phosphorus concentrations in the pond ranged from 0.031 to 0.065 mg/L, averaging 0.046 mg/L. Outlet TP concentrations ranged from .028 to .044 mg/L.

The current year data (see Figure 14) show that the total phosphorus concentration fluctuated throughout the season.

The historical data show that the 2004 mean total phosphorus concentration is much greater than the state median.

Overall, visual inspection of the historical data trend line show an increasing total phosphorus trend, which means that the concentration has worsened since monitoring began in 2000.

Transparency

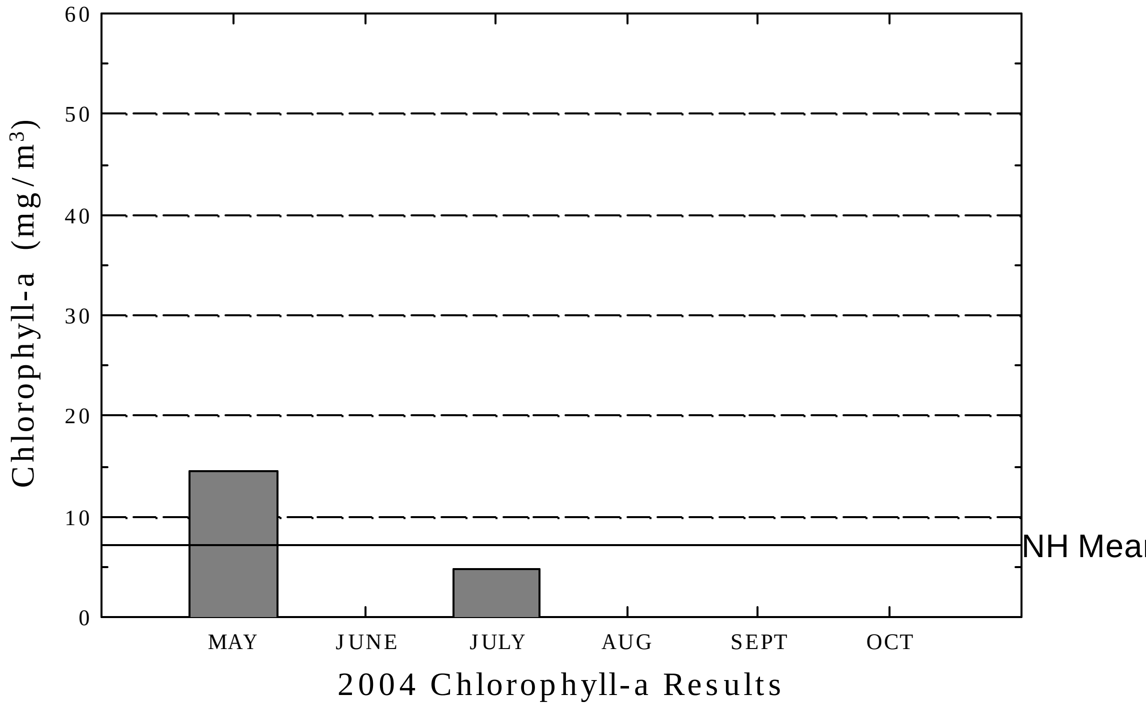
No data are available for transparency, as the pond is too shallow for this test. The bottom of the pond is visible.

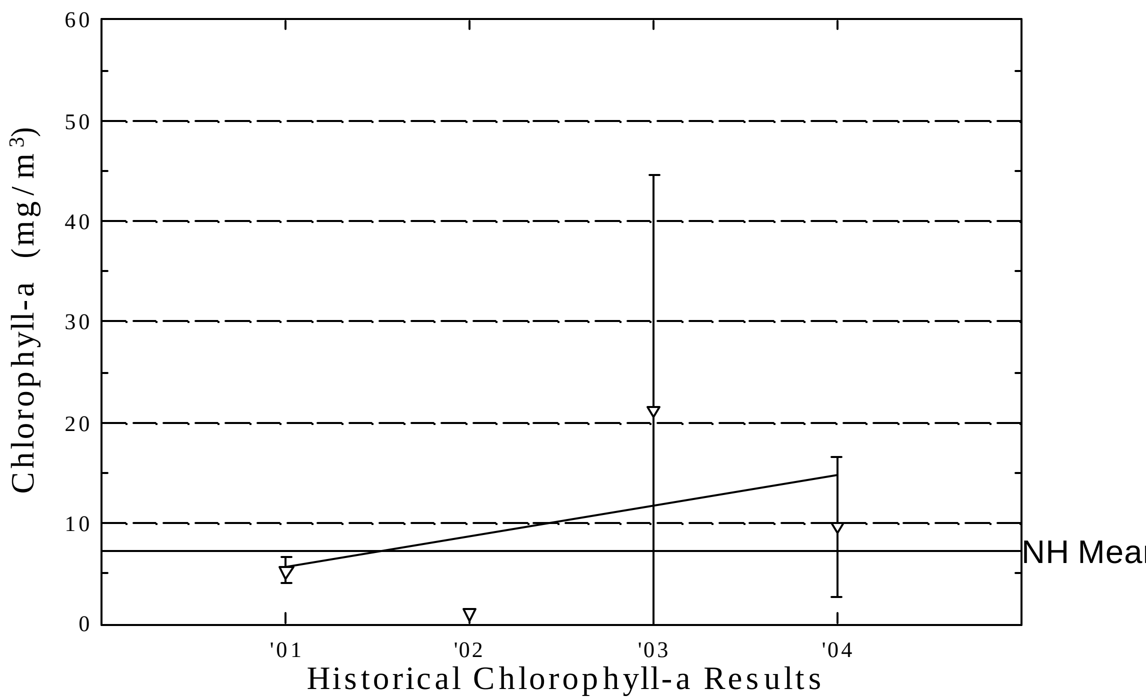
Turbidity

Pond turbidity ranged from 3.46 to 4.78 NTU and averaged 4.15 NTU. Outlet turbidity ranged from 2.21 to 6.61 NTU and averaged 4.12 NTU.

McQuesten Pond, Manchester

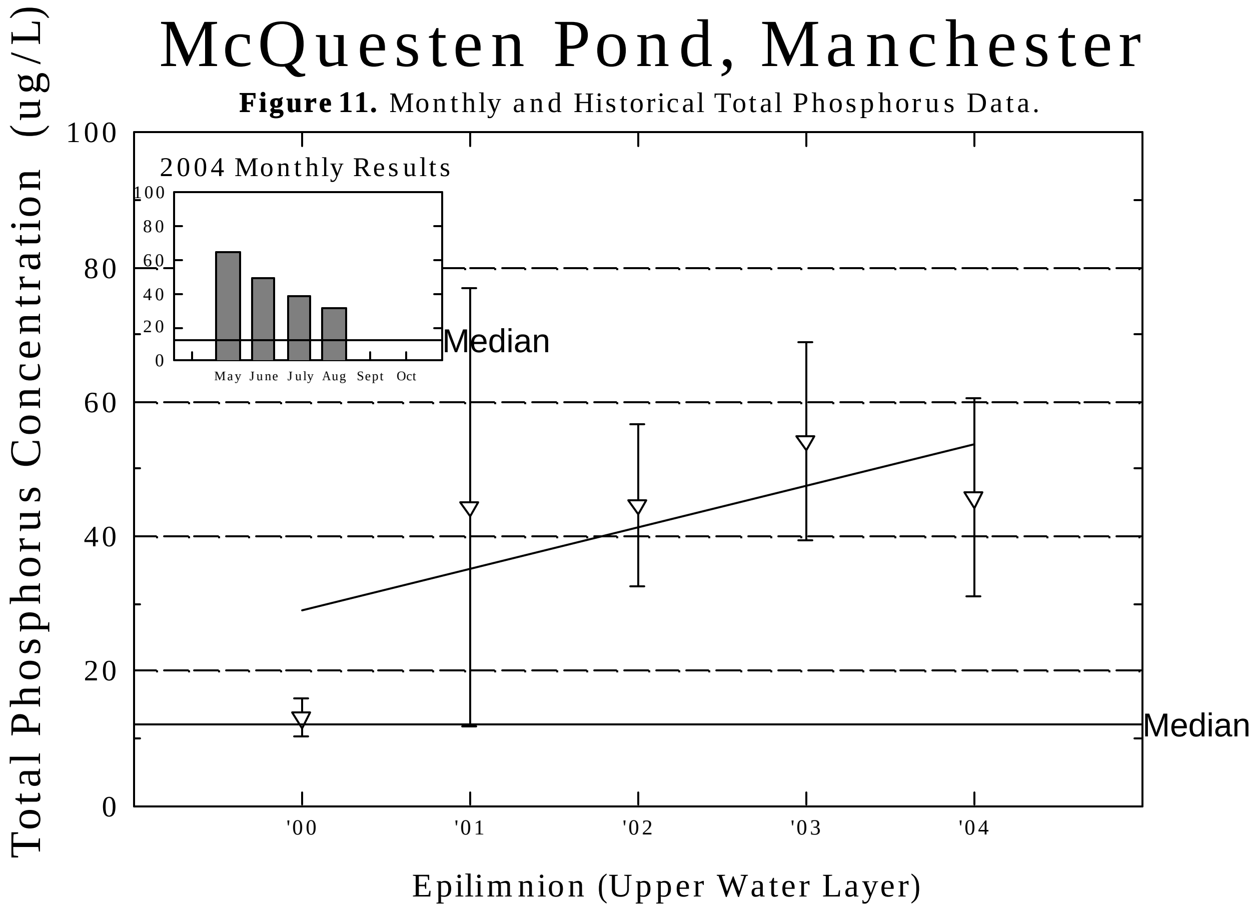
Figure 10. Monthly and Historical Chlorophyll-a Results





McQuesten Pond, Manchester

Figure 11. Monthly and Historical Total Phosphorus Data.



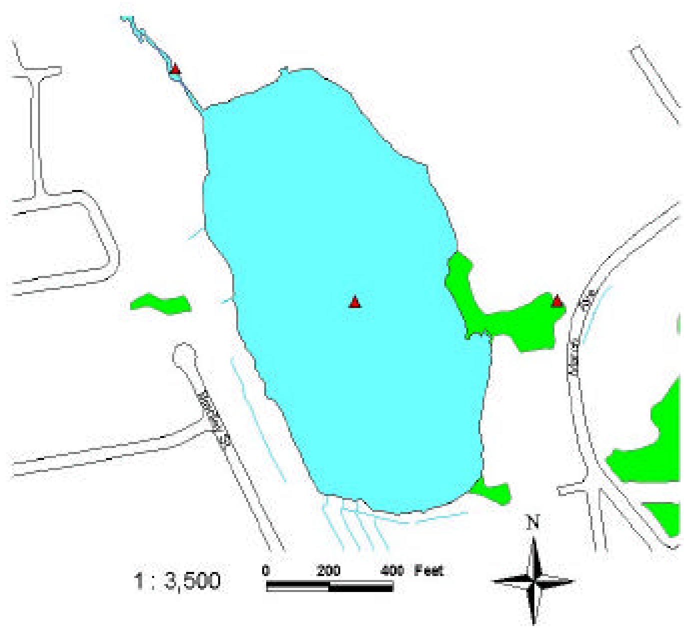
NUTTS POND

Nutts Pond. Photo by Jen Drociak

- **Namesake:** Named after a historic local circus performer, "Commodore Nutt"
- **Location:** Driving Park Road, off of South Willow Street in south Manchester
- **Type of Waterbody:** Natural pond
- **Inlet/Outlet:** Tannery Brook, flowing into Nutts Pond to the south of Home Depot, and emptying into the Merrimack River near the Riverwalk in downtown Manchester
- **Watershed Area:** 415 acres (168 hectares)
- **Waterbody Size:** 16.1 acres (6.52 hectares)
- **Volume of Water:** 260,500 m3
- **Mean/Average Water Depth:** 13.12 feet (4.0 meters)
- **Maximum Water Depth:** 30.18 feet (9.2 meters)
- **Shoreline Length:** 3,116 feet (950 meters)
- **Elevation:** 237 feet
- **Flushing Rate:** 3.1 times/year
- **Uses:** Paddling, fishing
- **Amenities:** Precourt Park athletic fields
- **Local Legend:** "Commodore Nutt" the circus midget who toured with the P.T. Barnum Circus show with Tom Thumb

Water Quality

The Nutts Pond watershed consists of strip malls, industrial lots, streets, and residential neighborhoods. Runoff to Nutts Pond receives little to no treatment. Since heavy development began in the area approximately 30 years ago, sediment and pollution has been accumulating in stormwater created deltas at four points in the pond (N, E, S, W). The pond has high levels of heavy metals in the water column and is heavily influenced by ground water. At this point it remains unknown if the metals found in the water column (particularly iron) are derived from groundwater or other possible sources (such as accumulated debris in the pond or street runoff). Wet weather sampling of Nutts Pond inlets in 2002 did not show unusually high iron concentrations. Nutts Pond has shown steady decline in water quality over the last twenty years, as the table below indicates.



Chlorophyll-*a*

Composite chlorophyll-*a* concentrations for the upper metalimnion and epilimnion ranged from 10.24 to 26.93 mg/m^3 and averaged 19.31 mg/m^3. This is a high concentration considering the "typical" value for a NH lake is 3.9 mg/m^3. Chlorophyll-*a* concentration varied greatly throughout the season. Compared to 2001 through 2003, the 2004 mean has worsened, but is still better than the mean chlorophyll-*a* concentration in 2000 (27.42 mg/m^3). Keep in mind that this is a limited data set.

The current year data (see Figure 16) shows that 2004 chlorophyll-*a* levels were variable, but never dropped below the state mean. Overall, visual inspection of the historical data trend also shows a variable but consistently high chlorophyll-*a* mean.

After 10 consecutive years of sample collection from the lake/pond, we could conduct a statistical analysis of the data. This will allow us to objectively determine if there has been a significant change in the annual mean chlorophyll-a concentration since monitoring began. For data less than 10 years, it is difficult to definitively say whether a trend exists.

Chloride

This year was the third year that the chloride concentration was measured at the deep spot of the pond. In New Hampshire, the median chloride concentration for lakes/ponds is 5.0 mg/l. The average epilimnetic chloride level in Nutts Pond was 147 mg/L. The hypolimnetic average was 611 mg/L. These readings are similar to the levels found in 2002 and 2003.

Conductivity

Conductivity levels were very high, especially in the hypolimnion, where readings ranged from 1980 to 2360 uMhos/cm, and averaged 2193.3 uMhos/cm. This is related to metals contamination in the water column. Epilimnion conductivity ranged from 439 to 877 uMhos/cm, and averaged 598.8 uMhos/cm. These numbers represent the highest average hypolimnion conductivity readings ever recorded at Nutts Pond.

Dissolved Oxygen (DO)

Nutts Pond was stratified before sampling began in April of 2004. Each sampling session identified a clearly defined epilimnion, metalimnion, and hypolimnion. Hypolimnion dissolved oxygen was at its lowest in the April. These anoxic (very low oxygen) conditions are causing internal phosphorus loading in Nutts Pond. In other words, the low oxygen is causing organisms in the pond to release phosphorus from the sediments.

The dissolved oxygen concentration was greater than 100% saturation in the upper layers at the deep spot on the April, June and August sampling events. In September, supersaturation extended through the hypolimnion, to the pond bottom. This occurrence is believed to have been caused by seasonal turnover. High amounts of oxygen in the upper layers of the water column can be the result of two different conditions.

Layers of algae can raise the dissolved oxygen in the water column, since oxygen is a by-product of photosynthesis. Considering that the depth of the photic zone (depth to which sunlight can penetrate into the water column) was approximately 1.1 to 2.3 meters on these sampling dates (as shown by the Secchi-disk transparency), and that the metalimnion (layer of rapid decrease in water temperature and increase in density – a place where algae are often found) was located between approximately 2 and 5 meters, we suspect that an abundance of algae may have contributed to the oxygen super saturation.

Wave action from wind can also dissolve atmospheric oxygen into the upper layers of the water column. Considering that windy conditions were indicated on these dates, wave action may have also contributed to the oxygen super saturation.

The dissolved oxygen concentration was very low in the metalimnion and hypolimnion at the deep spot of the lake/pond early in the season, but improved as the season progressed. As stratified lakes/ponds age, oxygen becomes depleted in the hypolimnion (the lower layer) by the process of decomposition. Specifically, the loss of oxygen in the hypolimnion results primarily from the process of biological breakdown of organic matter both in the water column and particularly at the bottom of the lake/pond where the water meets the sediment. When oxygen levels are depleted to less than 1 mg/L in the hypolimnion (as it was this season and in past seasons), the phosphorus that is normally bound up in the sediment may be re-released into the water column.

During this season, and many past sampling seasons the lake/pond has had a lower dissolved oxygen concentration and a higher total phosphorus concentration in the hypolimnion than in the epilimnion These data suggest that the process of internal total phosphorus loading is occurring in the lake/pond. When oxygen levels are depleted to less than 1 mg/L in the hypolimnion (as it was this season and in many past seasons), the phosphorus that is normally bound up with metals in the sediment may be re-released into the water column. Depleted oxygen concentration in the hypolimnion of thermally stratified lakes/ponds typically occurs as the summer progresses.

pH and Acid Neutralizing Capacity (ANC)

Nutts Pond pH values varied very little, ranging from 6.46 to 6.73 and averaging 6.61. This is within the range considered ideal for freshwater ecosystems. The ANC values ranged from 12.5 to 14.4 mg of CaCO/L and averaged 13.45 mg/L.

Due to the presence of granite bedrock in the state and the deposition of acid rain, there is not much that can be done to effectively increase lake/pond pH.

Phosphorus (TP)

As expected, the concentrations of phosphorus were the highest in the hypolimnion ranging from 0.039 to 0.125 mg/L and averaging 0.082 mg/L. These are by far the highest TP concentrations of any Manchester pond. This is likely due to runoff from surrounding commercial and recreational areas and internal loading. Epilimnion TP values ranged from 0.013 to 0.039 mg/L and averaged 0.21 mg/L. These are similar to TP levels found in previous years.

The historical data (see Figure 18) for the epilimnion show that the 2004 total phosphorus mean is much greater than the state median. Overall, visual inspection of the historical data trend line for the epilimnion shows an increasing total phosphorus trend, which means that the concentration has worsened in the epilimnion since monitoring began.

The historical data for the hypolimnion show that the 2004 total phosphorus mean is greater than the state median. Overall, the historical data trend line for the hypolimnion shows an increasing total phosphorus trend, which means that the concentration has worsened in the hypolimnion since monitoring began.

Transparency

As in past years, Secchi disk transparency and chlorophyll-*a* content appeared to be related at Nutts Pond. In general, when chlorophyll-*a* was high, transparency was low. Transparency ranged from 1.1 to 3.05 meters, and averaged 1.8 meters.

The historical data (see Figure 17) show that the 2004 mean transparency is less than that of the state mean.

Overall, visual inspection of the historical data trend shows a relatively stable trend for in-lake transparency, meaning that the transparency has remained approximately the same since monitoring began.

Typically, high intensity rainfall causes erosion of sediments into the lake/pond and streams, thus decreasing clarity. Efforts should continually be made to stabilize stream banks, lake/pond shorelines, disturbed soils within the watershed, and especially dirt roads located immediately adjacent to the edge of tributaries and the lake/pond.

Turbidity

Turbidity was high in Nutts Pond, especially in the hypolimnion where values ranged from 34.2 to 135.0 (NTU) and averaged 76.3 (NTU). Epilimnion turbidity values were much lower, averaging 5.32 (NTU). The high turbidity in the hypolimnion may be due to metals contamination. Turbidity readings in 2004 were similar to those of previous years.

The turbidity of the hypolimnion sample was elevated on all sampling events this year, similarly to previous sampling seasons. This suggests that the lake/pond bottom *may* have been disturbed by the anchor or by the Kemmerer Bottle while sampling. When the lake/pond bottom is disturbed, sediment, which typically contains attached phosphorus, is released into the water column. The hypolimnion is also known to have high metals concentrations, which can be seen visually.

Table 8[1]: Nutts Pond Water Quality Comparison (1981-2004)

		pH	Alkalinity (mg/L)	Total Phosphorus (mg/L)	Conductivity (uMhos/cm)	Secchi Disk (m)	Chlorophyll *a* (mg/m3)
1981*		7.10	12.0	0.025	194.0	2.5	-
1995**		8.90	15.8	0.025	567.0	2.5	-
2000	Mean	6.77	13.9	0.015	488.0	3.1	27.42
	Median	6.79	14.1	0.013	454.0	3.3	21.12
2001	Mean	6.82	17.3	0.023	714.2	2.4	14.01
	Median	6.83	17.0	0.019	630.5	2.6	10.94
2002	Mean	6.77	15.4	0.024	580.4	2.9	10.81
	Median	6.77	15.4	0.024	546.0	2.9	7.73
2003	Mean	6.68	17.0	0.030	786.0	2.3	17.13
	Median	6.68	17.5	0.029	790.0	2.3	11.56
2004	Mean	6.61	13.5	0.021	598.8	1.8	19.31
	Median	6.60	13.4	0.017	574.5	1.7	20.66

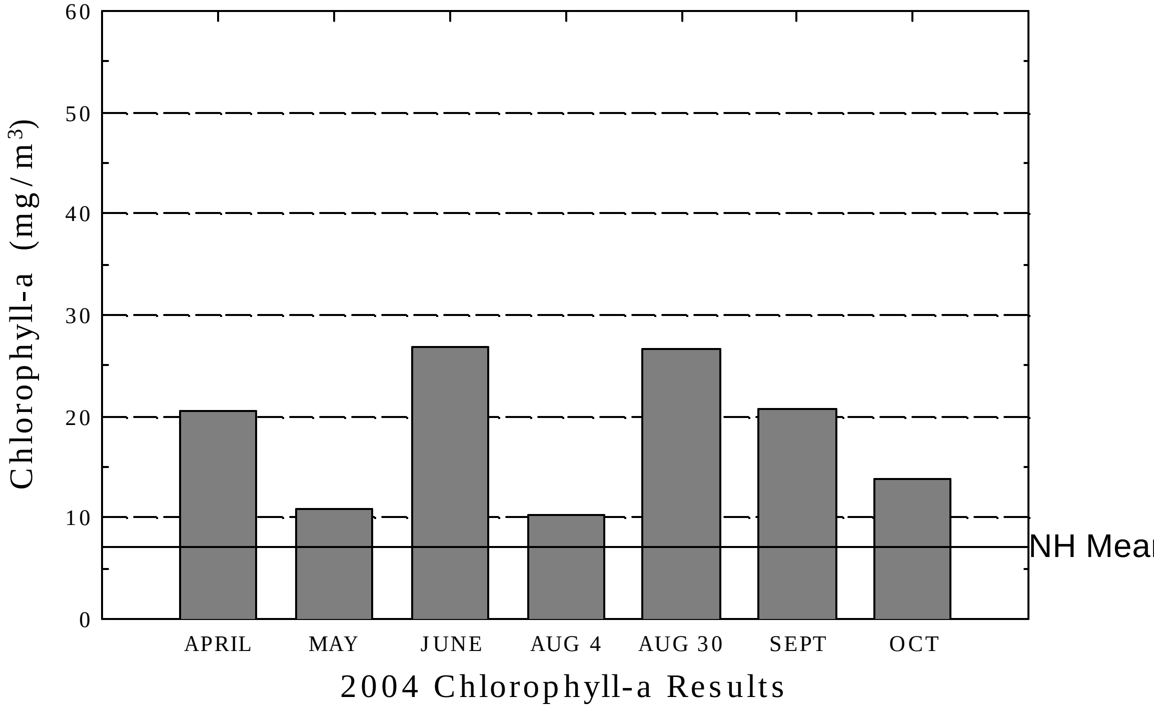
1) All values are epilimnetic.

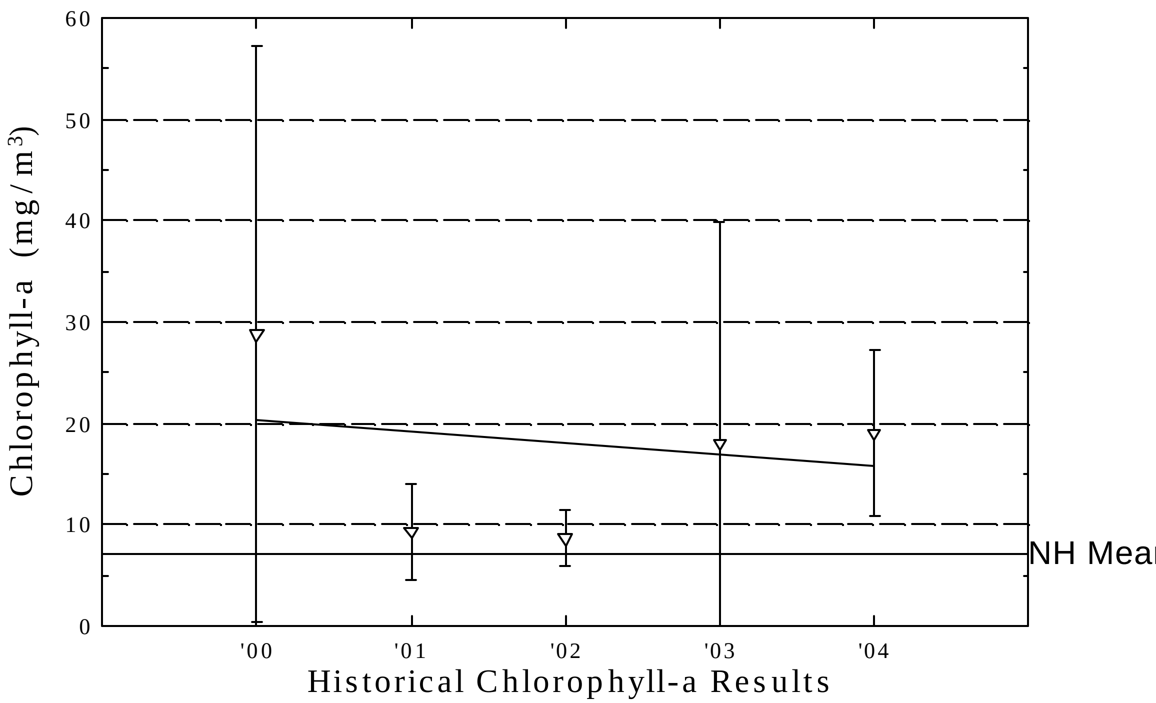
* NH Dept. of Environmental Services. 1981. Trophic Classification of NH Lakes and Ponds.

** NH Dept. of Environmental Services. 1996. Lake Trophic Data.

Nutts Pond, Manchester

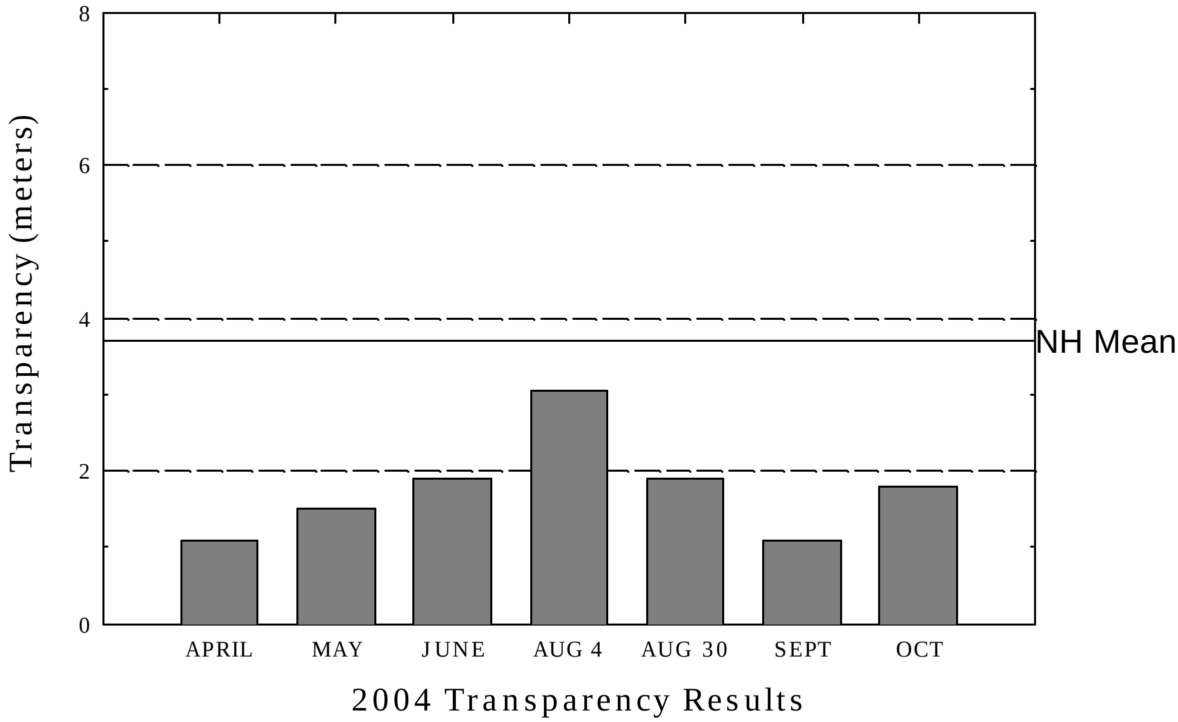
Figure 12. Monthly and Historical Chlorophyll-a Results

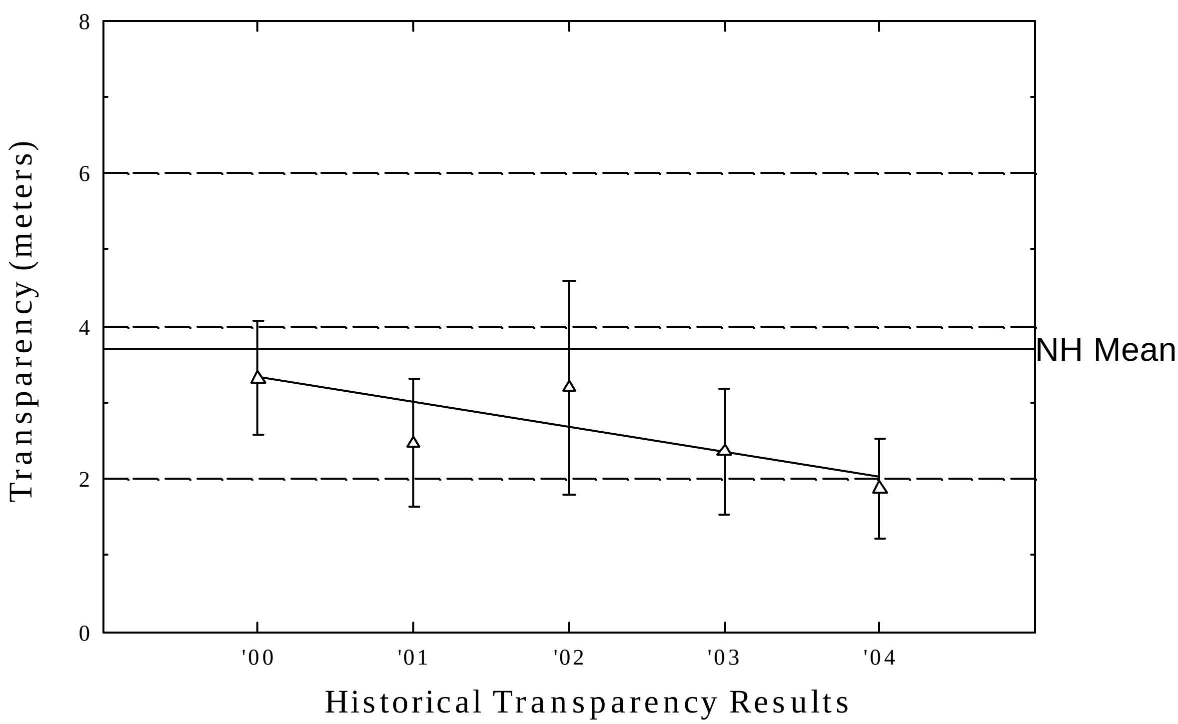




Nutts Pond, Manchester

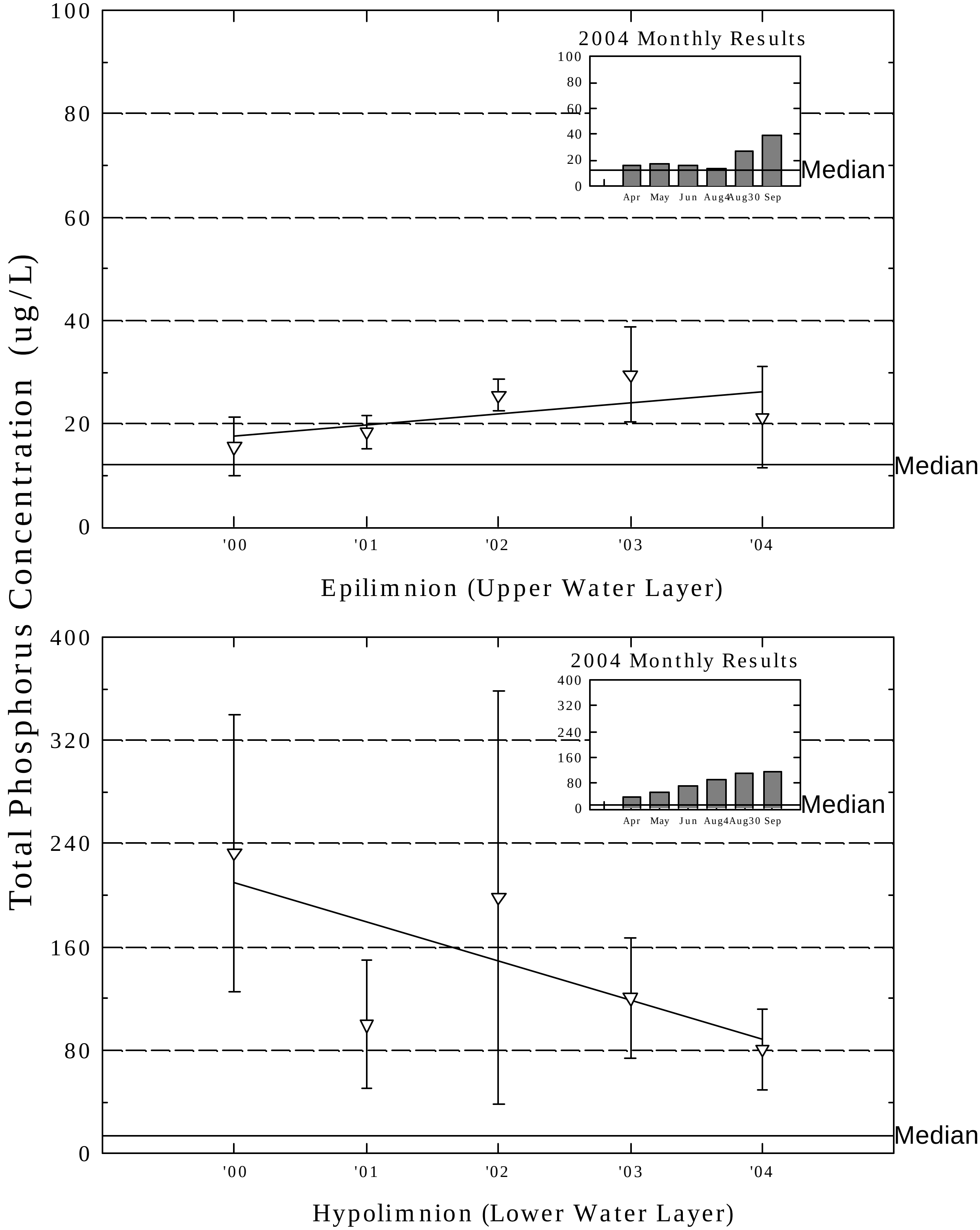
Figure 13. Monthly and Historical Transparency Results





Nutts Pond, Manchester

Figure 14. Monthly and Historical Total Phosphorus Data.



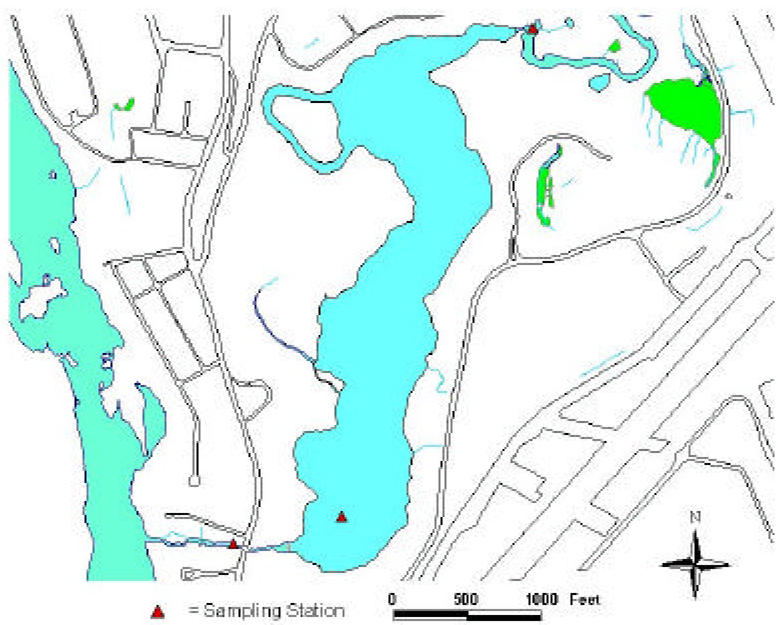
PINE ISLAND POND

Pine Island Pond. Photo by Art Grindle

- **Location:** East of Brown Avenue and abutting Manchester Airport to the west, in south Manchester
- **Type of Waterbody:** Artificial Pond created by impoundment on Cohas Brook
- **Inlet/Outlet:** Cohas Brook, beginning in the Great Cohas Swamp near Crystal Lake, and emptying into the Merrimack River adjacent to the airport in south Manchester
- **Watershed Area:** 44,186 feet (17,889 hectares)
- **Waterbody Size:** 42.4 acres (17.16 hectares)
- **Volume of Water:** 265,000 m3
- **Mean Water Depth:** 4.92 feet (1.5 meters)
- **Maximum Water Depth:**
- **Shoreline Length:** 11,103 feet (3,385 meters)
- **Elevation:** 151 feet
- **Percent of Watershed Ponded:** 7.7%
- **Flushing Rate:** 326 times/year
- **Uses:** Boating, fishing, occasional swimming
- **Amenities:** Pine Island Park playground
- **Local History:** Was home to a popular amusement park “Pine Island Park” from 1902-1962
- **Lake Association:** Pine Island Pond Environmental Society (PIPES)

Water Quality

Pine Island Pond water quality is still relatively good. It is still used for swimming, fishing and boating. Twenty years of increasing watershed development have impacted the pond, however. Pine Island Pond has seen a slow but steady decline in water quality over the past twenty years, but over the past three years has experienced fluctuations in water quality conditions.



Chlorophyll-*a*

Composite chlorophyll-*a* concentrations ranged from 2.94 to 16.09 mg/m^3 with an average of 8.97 mg/m^3.

The current year data (see Figure 20) show that the chlorophyll-*a* concentration increased gradually from April through July, then decreased.

The historical data show that the 2004 chlorophyll-a mean is slightly above the state mean. Overall, visual inspection of the historical data trend shows a decreasing in-lake chlorophyll-a trend, meaning that the concentration has improved since monitoring began. Please note that this trend is based on only five years of data.

After 10 consecutive years of sample collection for the pond, we will conduct a statistical analysis of the data. This will allow us to objectively determine if there has been a significant change in the annual mean chlorophyll-a concentration since monitoring began.

Conductivity

Conductivity values were also relatively uniform throughout the water column. The epilimnion averaged 256.1 uMhos/cm. The hypolimnion averaged 268.1 uMhos/cm. All conductivity values are high when compared to a "natural, undisturbed lake", but have not changed drastically since 1981.

Dissolved Oxygen (DO)

Dissolved oxygen concentrations were fairly stable in 2004. The lowest DO readings were recorded in June.

The loss of oxygen in the hypolimnion results primarily from the process of biological breakdown of organic matter (i.e.; biological organisms use oxygen to break down organic matter), both in the water column and particularly at the bottom of the pond where the water meets the sediment.

pH and Acid Neutralizing Capacity (ANC)

Pine Island Pond pH values ranged from 6.27 to 6.73 and averaged 6.58. This is similar to pH values recorded in previous years. ANC values ranged from 5.0 to 17.5, and averaged 11.53 mg of CaCO/L. These readings indicate that Pine Island Pond has substantial buffering capacity. ANC, like pH, seems to remain steady year after year.

Phosphorus (TP)

As discussed above with low dissolved oxygen, an internal source of phosphorus in the pond may be present. Therefore, it is even more important that watershed residents act proactively to minimize external phosphorus loading from the watershed. For instance, picking up after pets, minimizing fertilizers on lawns, etc.

Pine Island Pond total phosphorus readings were relatively uniform throughout the water column, with the epilimnion averaging .024 mg/L and hypolimnion averaging .036 mg/L. These values are higher than those recorded in any previous year.

The historical data (see Figure 22) for the epilimnion show that the 2004 total phosphorus median is greater than the state median. Overall, visual inspection of the historical data trend for the epilimnion shows a variable, but increasing, total phosphorus trend, which means that the concentration has fluctuated in the epilimnion since monitoring began.

The historical data for the hypolimnion show that the 2004 total phosphorus median is also greater than the state median. Overall, visual inspection of the historical data trend for the hypolimnion shows a relatively stable, but increasing total phosphorus trend. As discussed previously, these trends are based on a limited data set.

Transparency

Secchi disk transparency dropped steadily as chlorophyll-*a* concentration increased, though there was some variability between these two parameters. Transparency ranged from 1.45 to 2.7 meters and averaged 1.8 meters. Pine Island Pond has a natural tea color caused by the presence of tannins (plant pigments). This condition limits water transparency. Average Secchi disk transparency has remained consistent near 1.9 meters for the past 4 years.

The historical data (see Figure 21) show that the 2004 mean transparency is less than the state mean. Overall, visual inspection of the historical data trend shows a steady trend for in-lake transparency, meaning that the transparency has remained similar since monitoring began.

Typically, high intensity rainfall causes erosion of sediments into the pond and streams, thus decreasing clarity. Efforts should continually be made to stabilize stream banks, pond shorelines, disturbed soils within the watershed, and especially dirt roads located immediately adjacent to the edge of tributaries and the pond.

Turbidity

Turbidity ranged from 1.85 to 4.62 (NTU) in the epilimnion and averaged 3.01 (NTU). Hypolimnion turbidity ranged from 2.95 to 16.10 (NTU). The peak turbidity was recorded in August, coinciding with high TP readings. This pattern also occurred in 2003, 2002 and 2001 at the end of the summer season.

Pine Island Pond experiences high turbidity levels as a natural condition of its tannic waters.

Table 9[1:] Pine Island Pond Water Quality Comparison (1980-2004)

		PH	Alkalinity (mg/L)	Total Phosphorus (mg/L)	Conductivity (uMhos/cm)	Secchi Disk (m)	Chlorophyll *a* (mg/m³)
8/5/80*		7.10	15.20	0.015	142.8	2.0	-
7/24/97**		7.20	20.60	0.018	290.4	1.4	-
2000	Mean	6.97	17.10	0.024	287.1	1.9	8.0
	Median	7.07	19.50	0.024	308.0	1.9	8.6
2001	Mean	7.00	20.10	0.016	383.3	1.9	13.2
	Median	7.04	21.00	0.017	412.5	1.7	11.4
2002	Mean	6.86	21.20	0.023	316.1	1.9	8.23
	Median	6.93	24.50	0.026	357.5	2.0	7.38
2003	Mean	6.65	14.60	0.029	338.5	1.9	2.21
	Median	6.64	16.00	0.033	364.5	1.8	2.63
2004	Mean	6.58	11.53	0.024	256.1	1.8	8.97
	Median	6.64	11.75	0.026	241.0	1.6	9.22

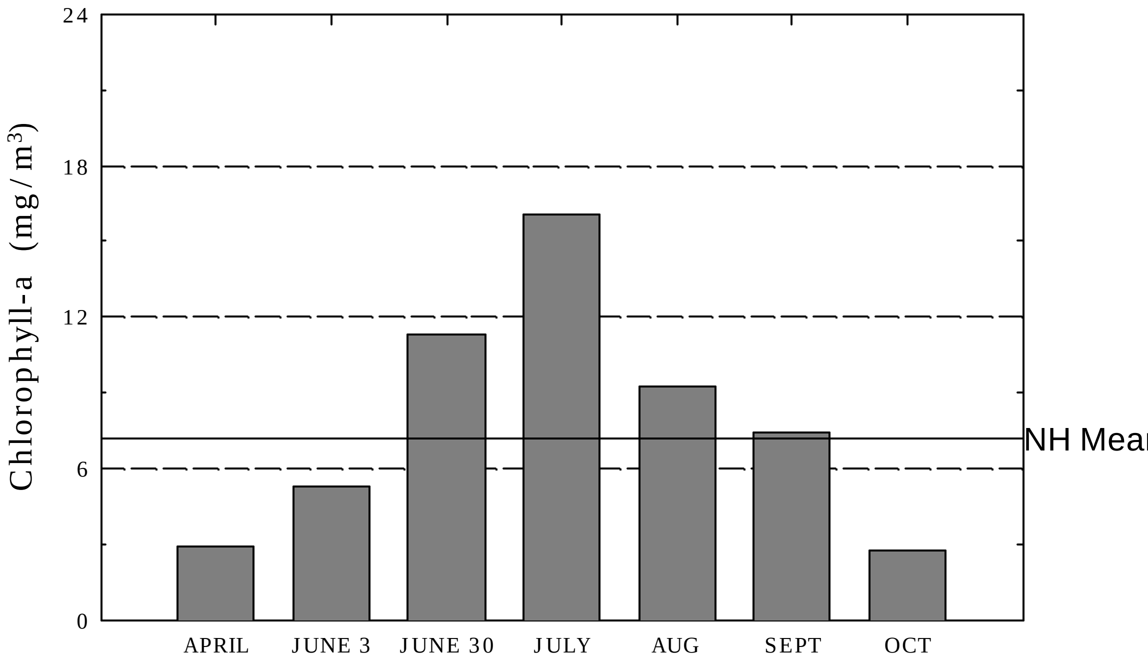
1) All values are epilimnetic.

* NH Dept. of Environmental Services. 1980. Trophic Classification of NH Lakes and Pond.

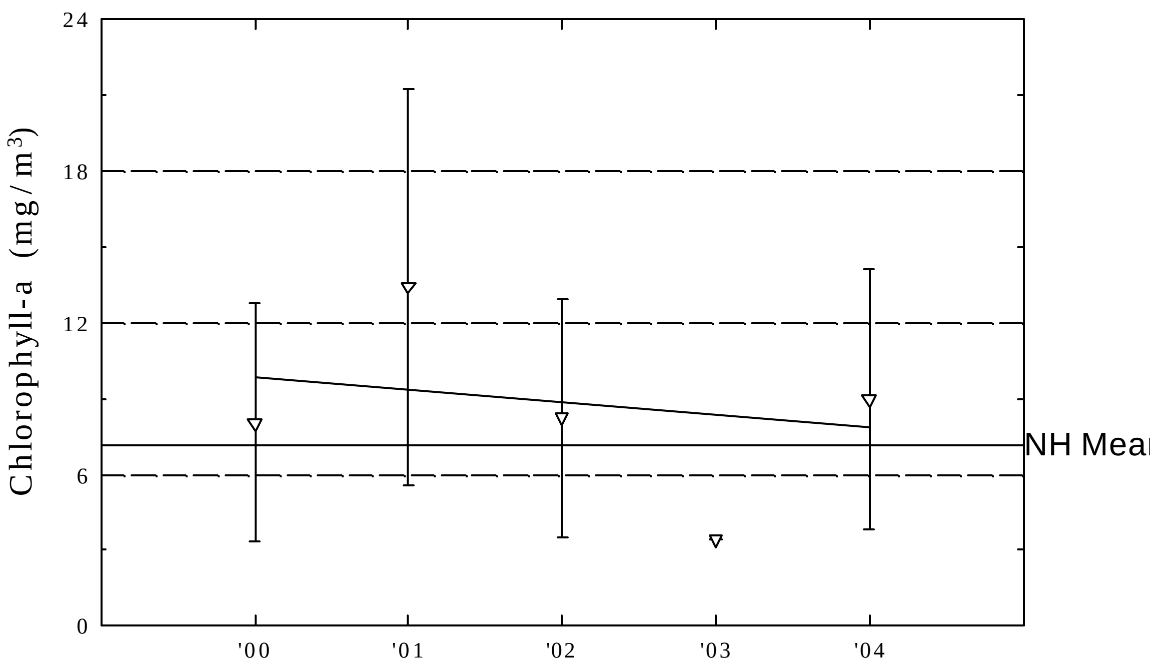
** NH Dept. of Environmental Services. 1998. Lake Trophic Data.

Pine Island Pond, Manchester

Figure 15. Monthly and Historical Chlorophyll-a Results



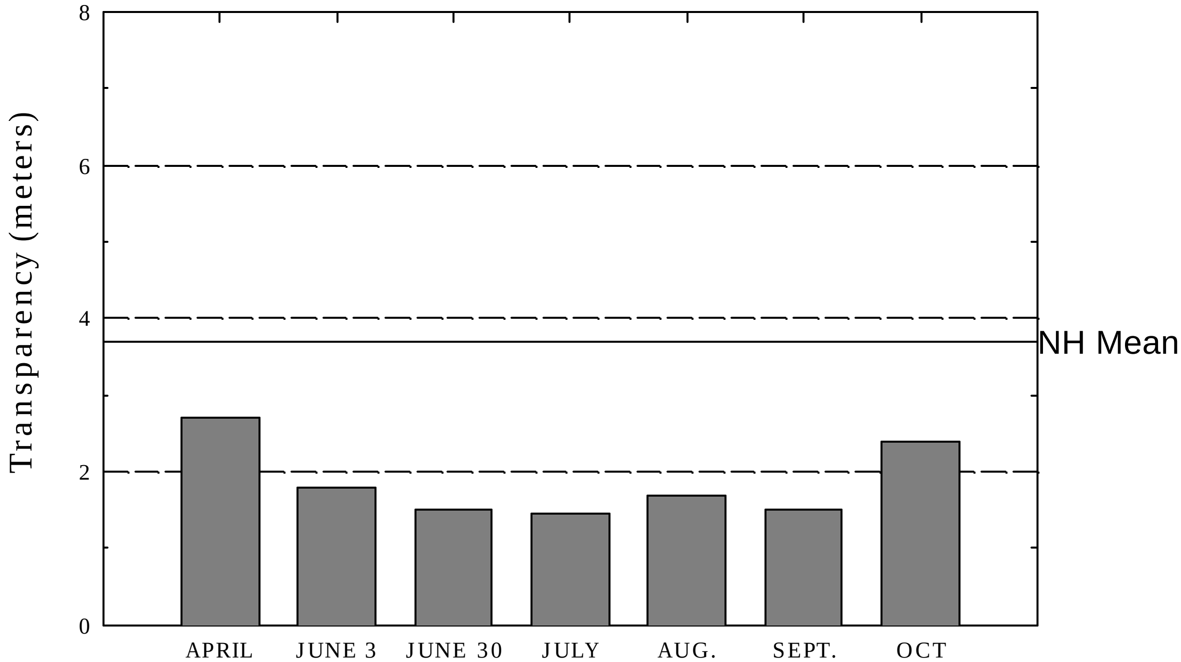
2004 Chlorophyll-a Results



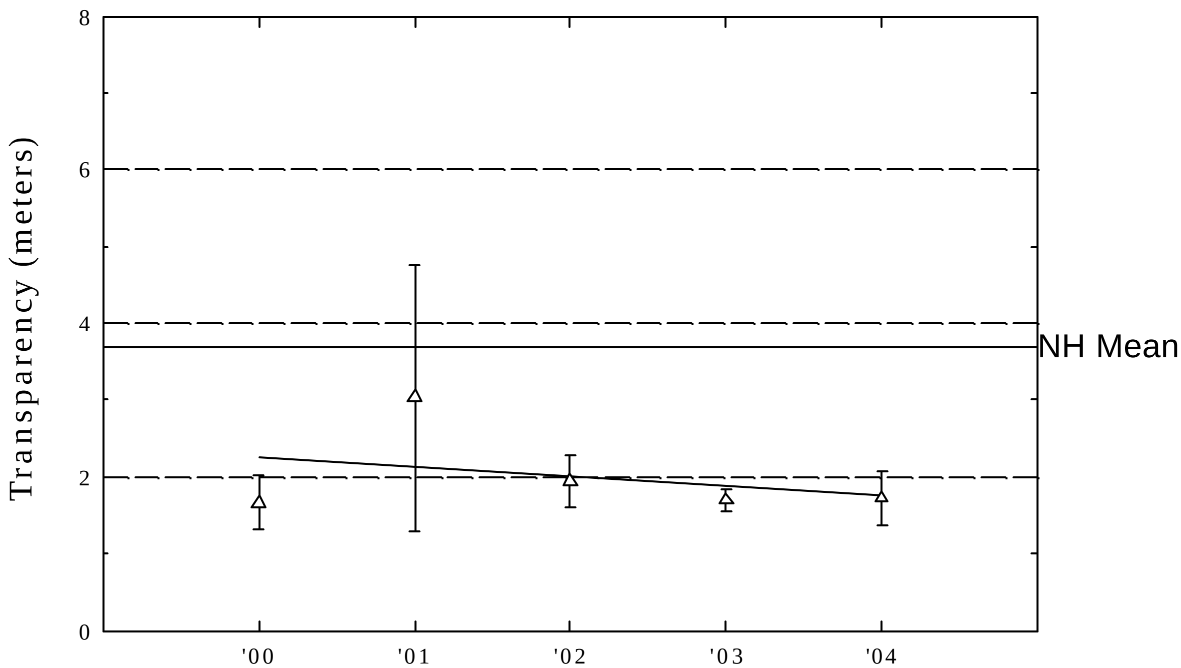
Historical Chlorophyll-a Results

Pine Island Pond, Manchester

Figure 16. Monthly and Historical Transparency Results



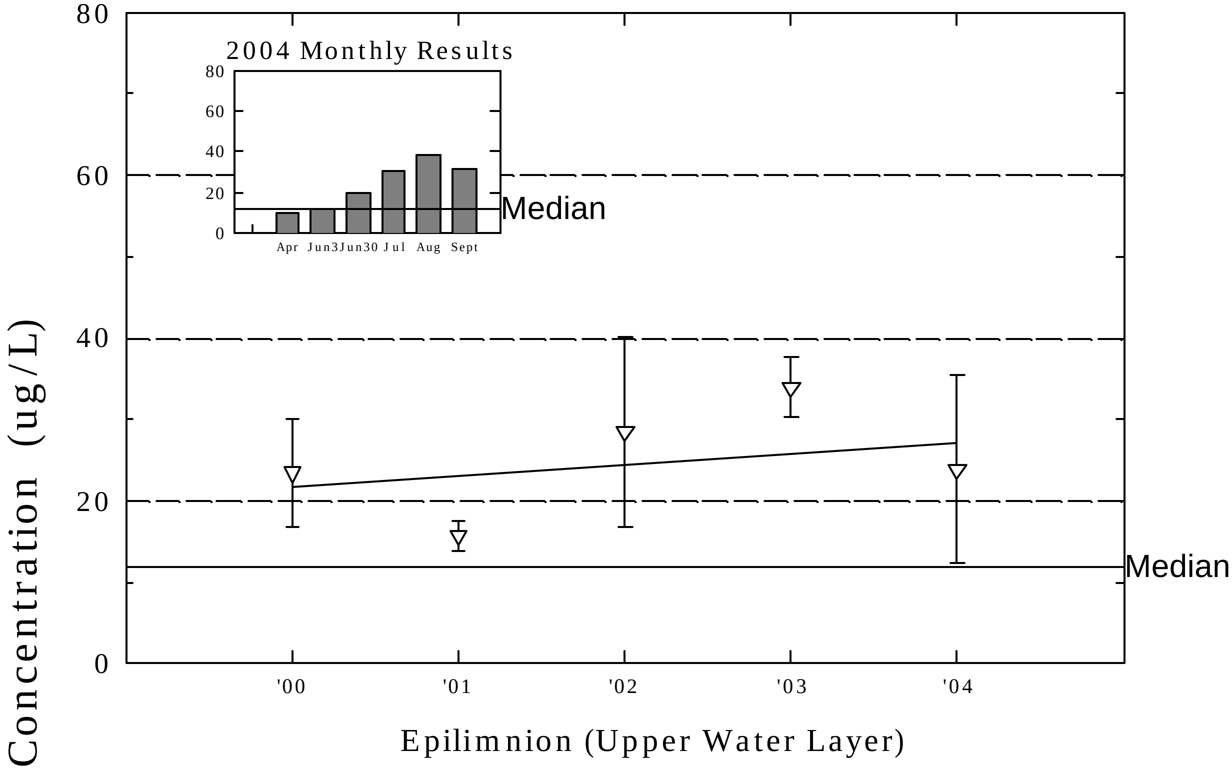
2004 Transparency Results

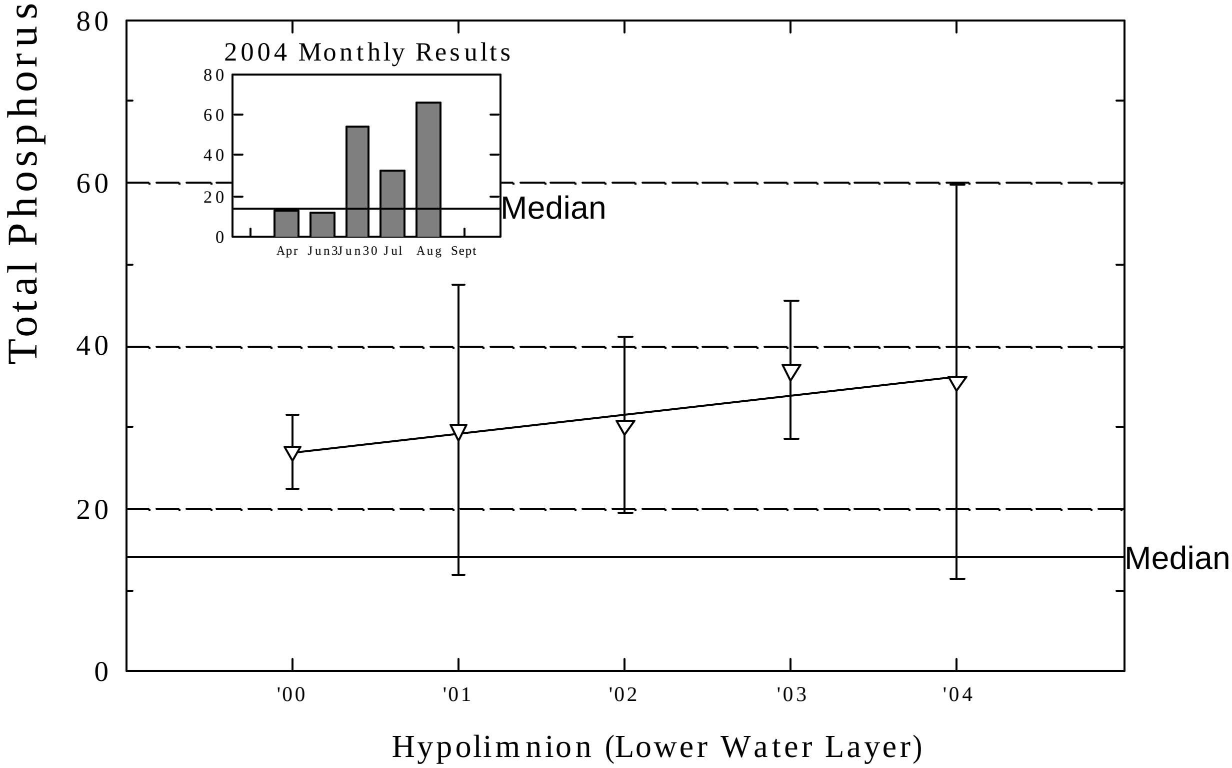


Historical Transparency Results

Pine Island Pond, Manchester

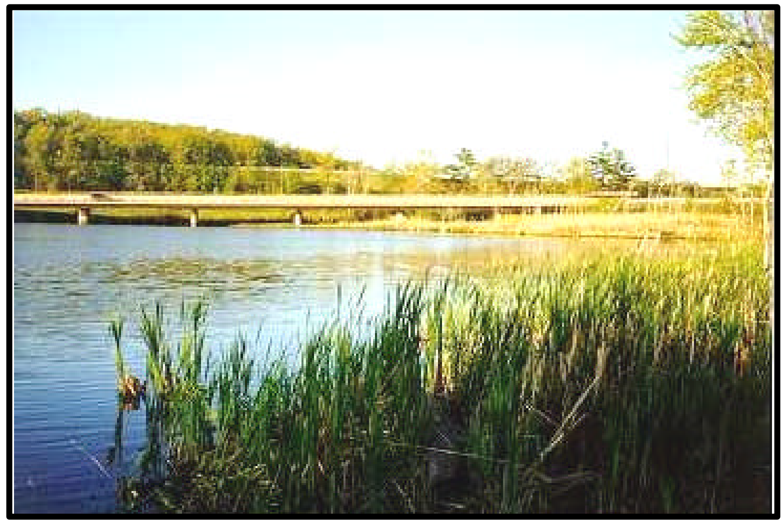
Figure 17. Monthly and Historical Total Phosphorus Data.





STEVENS POND

- **Location:** Bridge Street Extension, adjacent/under I93 in east Manchester
- **Type of Waterbody:** Natural Pond
- **Inlet/Outlet:** The outlet, Cemetery Brook, flows underneath east Manchester and empties into the Merrimack River near the Riverwalk in downtown Manchester
- **Watershed Area:** 444.6 acres (180 hectares)
- **Waterbody Size:** 15.5 acres (6.27 hectares)
- **Volume of Water:** 176,000 m3
- **Mean/Average Water Depth:** 9.18 feet (2.8 meters)
- **Maximum Water Depth:** 17.06 feet (5.2 meters)
- **Shoreline Length:** 3,526 feet (1,075 meters)
- **Elevation:** 315 feet
- **Flushing Rate:** 4.9 times/year
- **Uses:** Paddling, fishing, ice-skating
- **Amenities:** Steven's Park athletic fields to the east

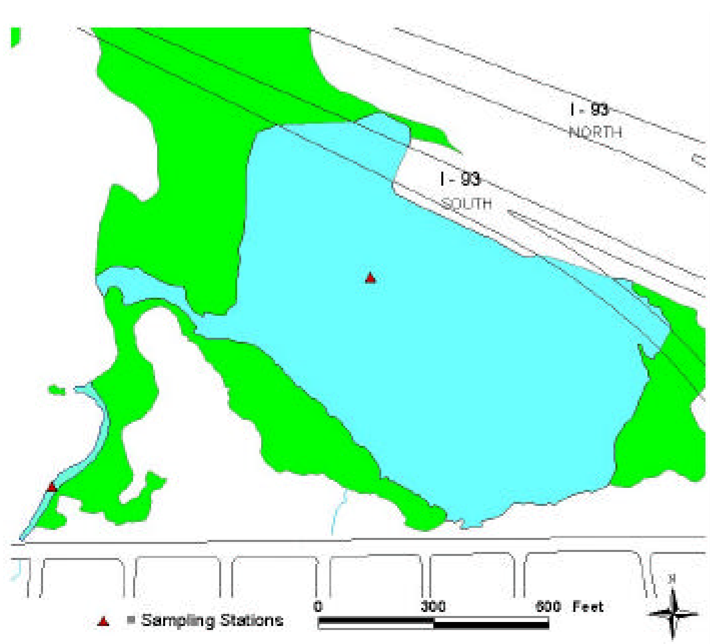


Stevens Pond. Photo by Cyndy Carlson

Water Quality

For more than 30 years, Stevens Pond has been impacted by untreated highway runoff from Interstate 93. De-icing activities and automotive byproducts have led to the serious degradation of a popular fishing and swimming spot in Manchester. Increasing residential development in the watershed is also an issue of concern.

Stevens Pond has been severely impacted by development. Eutrophication is being accelerated by highway runoff. Chloride and sodium levels are among the highest ever recorded in a freshwater body in New Hampshire. Significant decline cannot be seen over the past twenty years, with the exception of conductivity levels. Stevens Pond accelerated eutrophication apparently began before documentation of conditions in 1981.



Chlorophyll-*a*

Composite chlorophyll-*a* concentrations for the upper metalimnion and epilimnion ranged from 3.86 to 11.48 and averaged 9.44 mg/m^3. This is double the average chlorophyll-*a* concentration compared to last year.

The historical data (see Figure 24) show that the 2004 chlorophyll-*a* mean is slightly higher than the state mean for 2004. Overall, chlorophyll-*a* concentration rose sharply in the spring, but fluctuated little over the season.

Overall, visual inspection of the historical data trend shows a varied in-lake chlorophyll-*a* trend, meaning that the concentration has fluctuated year to year since monitoring began in 2000. However, please keep in mind that this trend is based on a limited amount of data.

Chloride

This year was the third year that the chloride concentration was measured at the deep spot of the lake. In New Hampshire, the median chloride concentration for lakes/ponds is 5.0 mg/L. The chloride in Stevens Pond ranged from 181 mg/L to 282 mg/L in the epilimnion, and 262 mg/L to 312 mg/L in the hypolimnion. The highest concentrations were recorded earliest in the season. Concentrations gradually decreased through the season. The increase of chloride concentration from the epilimnion to the hypolimnion may indicate the presence of a chemocline.

Conductivity

Conductivity levels remained relatively constant throughout the season and throughout the water column with peak conductivity occurring in April (same as 2002 and 2003). Epilimnion conductivity ranged from 702 to 1030 and averaged 860.4 uMhos/cm. Metalimnion conductivity ranged from 707 to 906 and averaged 829.0 uMhos/cm. Hypolimnion conductivity ranged from 963 to 1105 and averaged 1040.8 uMhos/cm. These numbers are lower than those recorded in 2003. In general, levels were highest at the beginning of the season and gradually decreased through the season. These are very high readings, indicative of a very degraded water body.

Typically, sources of elevated conductivity are due to human activity. These activities include septic systems that fail and leak leachate into the groundwater (and eventually into the tributaries and the lake), and stormwater runoff from urbanized areas (which typically contains road salt during the spring snow melt). In addition, natural sources, such as iron deposits in bedrock, can influence conductivity. Due to the history and present status of this highly urbanized watershed, and proximity of I-93, the high conductivity levels in the pond are probably in part due to runoff from the overpass.

Dissolved Oxygen (DO)

Thermal stratification was already apparent at Stevens Pond when monitoring began in late April. DO was relatively stable throughout the water column in 2004. Unlike previous years, super-saturation of dissolved oxygen was not observed in 2004. Super-saturation is a condition where the water holds greater than 100% of the expected maximum concentration of oxygen.

The dissolved oxygen concentration was lowest in the hypolimnion in April when it reached 49%. However, DO was high in the hypolimnion in August. As lakes/ponds age, oxygen becomes depleted in the hypolimnion by the process of decomposition. Specifically, the loss of oxygen in the hypolimnion results primarily from the process of biological breakdown of organic matter (i.e.; biological organisms use oxygen to break down organic matter), both in the water column and particularly at the bottom of the lake/pond where the water meets the sediment. Depleted oxygen concentration in the hypolimnion of thermally stratified lakes/ponds typically occurs as the summer progresses.

pH and Acid Neutralizing Capacity (ANC)

Stevens Pond pH ranged from 6.68 to 7.07 and averaged 6.92. There was no significant change in pH between 2002 and 2004. ANC values ranged from 21.4 to 33.7 mg/L of CaCO. ANC averaged 29.1 mg/L of CaCO. Stevens Pond has a high buffering capacity. There was has been no significant change in ANC since 2000.

Phosphorus (TP)

Total phosphorus levels in the hypolimnion ranged from .049 to .104 with an average of .081 mg/L. This is a significant increase over 2003 hypolimnion TP levels. High TP levels in the hypolimnion may indicate internal loading. Epilimnion TP levels ranged from .012 to .036 with an average of .022 mg/L. This is an increase from 2003.

The historical data (see Figure 26) for the epilimnion show that the 2004 total phosphorus median is *greater than* the state median. Overall, visual inspection of the historical data trend for the epilimnion shows a stable total phosphorus trend, which has been greater than the state median since monitoring began.

The historical data for the hypolimnion show that the 2004 total phosphorus median is much greater than the state median. Total phosphorus concentration in the hypolimnion peaked in late June then declined gradually.

Overall, visual inspection of the historical data trend for the hypolimnion shows a stable total phosphorus trend, which has been much greater than the state median since monitoring began.

Transparency

Secchi disk readings ranged from 2.1 to 3.0 and averaged 2.6 meters. As in past years, transparency did not appear to be directly affected by chlorophyll-*a* content.

Overall, visual inspection of the historical data trend (see Figure 25) shows a steady trend for in-lake transparency since monitoring began in 2000.

As discussed previously, after at least 10 consecutive years of sample collection, we will conduct a statistical analysis of the data to objectively determine long-term trends in lake quality.

Turbidity

As expected, Stevens Pond turbidity values were highest in the hypolimnion. This may be caused by high levels of sodium and chloride in the bottom sediments. Hypolimnion turbidity ranged from 3.63 to 35.20 with an average of 22.87 (NTU). Epilimnion and metalimnion turbidity values averaged 2.30 and 3.84 respectively. These turbidity levels represent an overall increase from 2003.

Table 10[1]: Stevens Pond Water Quality Comparison (1981-2004)

		pH	**Alkalinity** (mg/L)	**Total Phosphorus** (mg/L)	**Conductivity** (uMhos/cm)	**Secchi Disk** (m)	**Chlorophyll-a** (mg/m^3)
7/29/81*		7.20	33.0	0.028	301.00	2.0	-
7/23/97**		7.70	31.8	0.028	696.00	1.3	-
2000	Mean	7.11	34.2	0.019	769.00	2.6	8.68
	Median	7.15	34.8	0.019	765.50	2.6	4.08
2001	Mean	7.14	31.0	0.025	1148.8	2.5	6.26
	Median	7.20	32.7	0.028	1128.0	2.6	4.60
2002	Mean	7.03	30.8	0.018	1140.0	3.0	10.32
	Median	7.10	31.4	0.018	1102.0	2.9	3.20
2003	Mean	7.01	29.2	0.017	1257.8	1.7	4.28
	Median	7.08	31.6	0.017	1229.5	1.3	3.65
2004	Mean	6.92	29.1	0.022	860.40	2.6	9.44
	Median	6.93	30.3	0.018	876.00	2.7	11.21

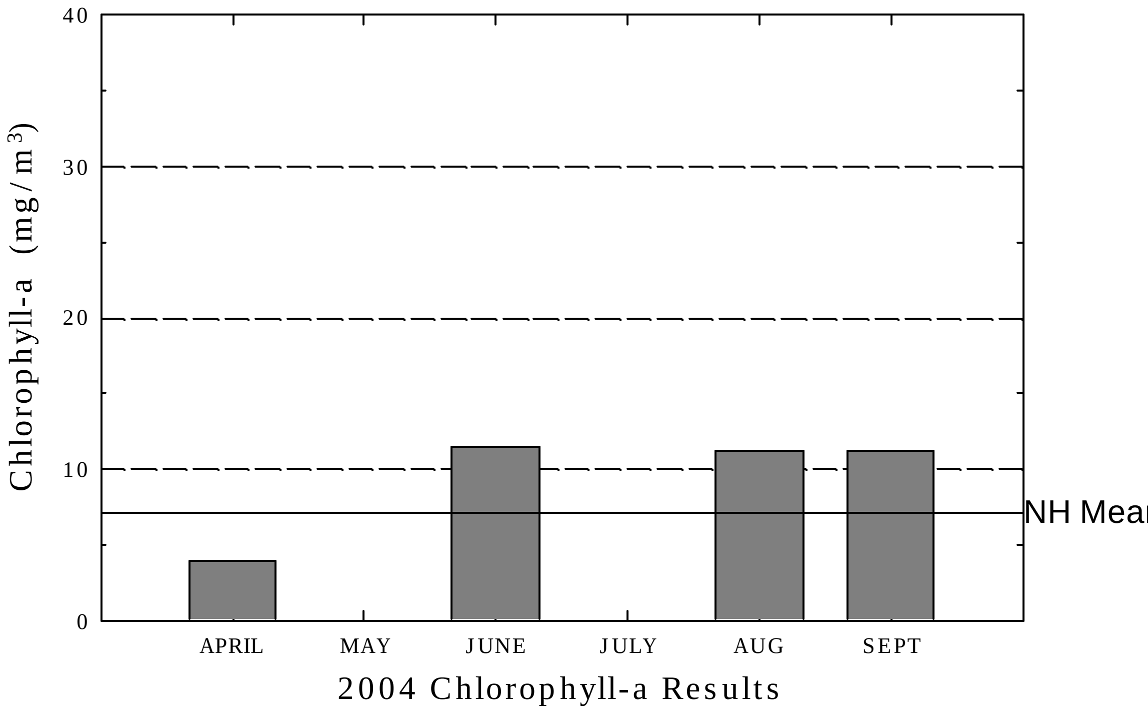
1) All values are epilimnetic.

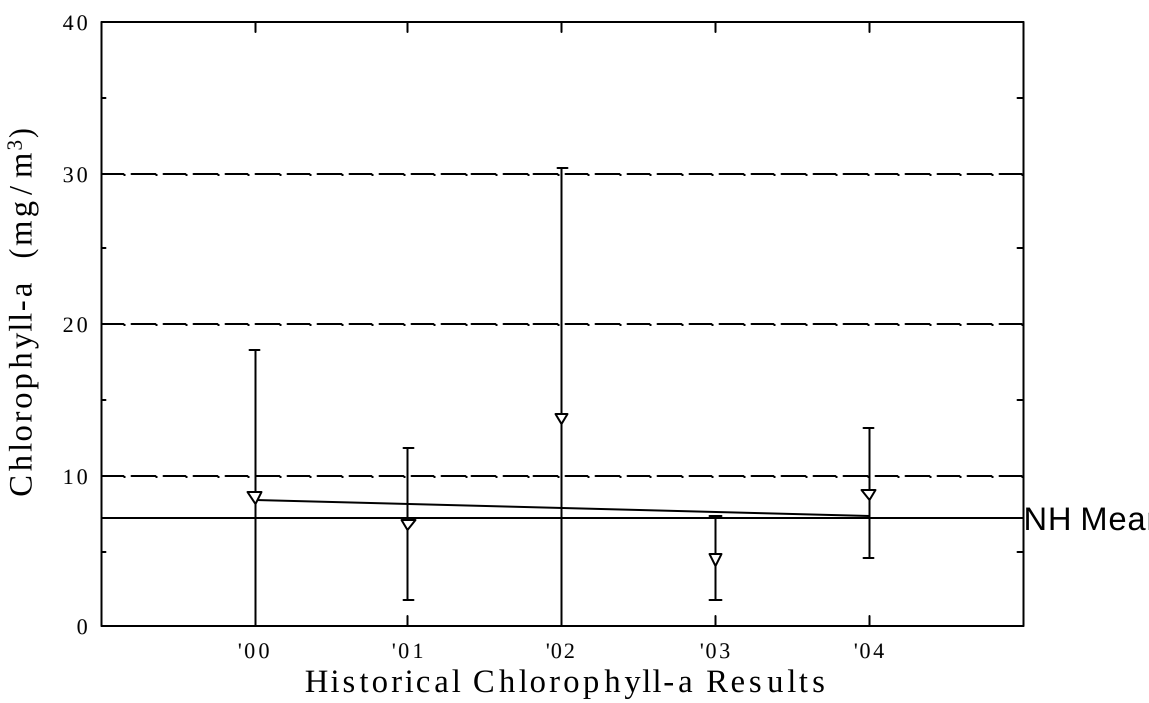
* NH Dept. of Environmental Services. 1981. Trophic Classification of NH Lakes and Ponds.

** NH Dept. of Environmental Services. 1998. Lake Trophic Data.

Stevens Pond, Manchester

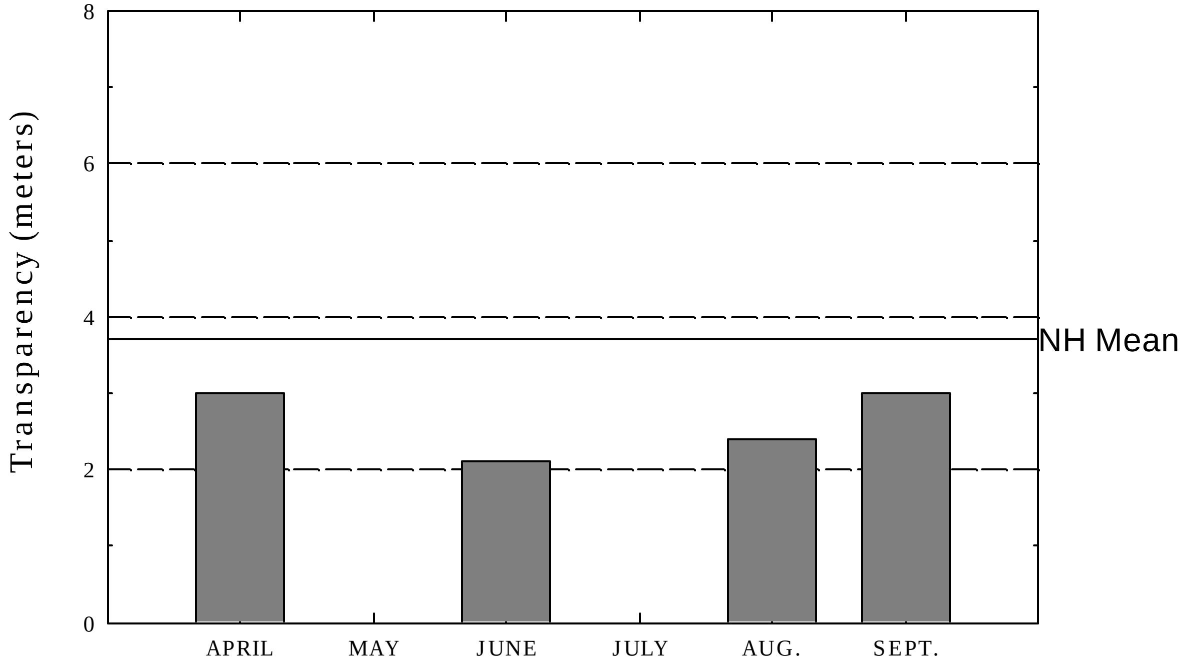
Figure 18. Monthly and Historical Chlorophyll-a Results



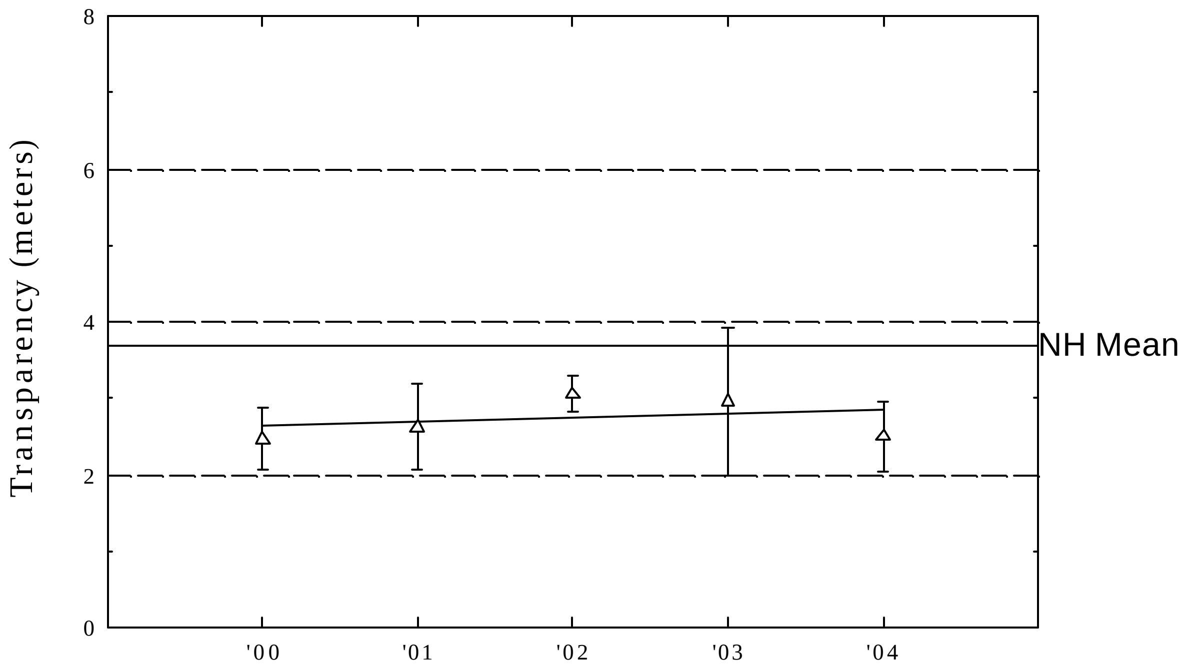


Stevens Pond, Manchester

Figure 19. Monthly and Historical Transparency Results



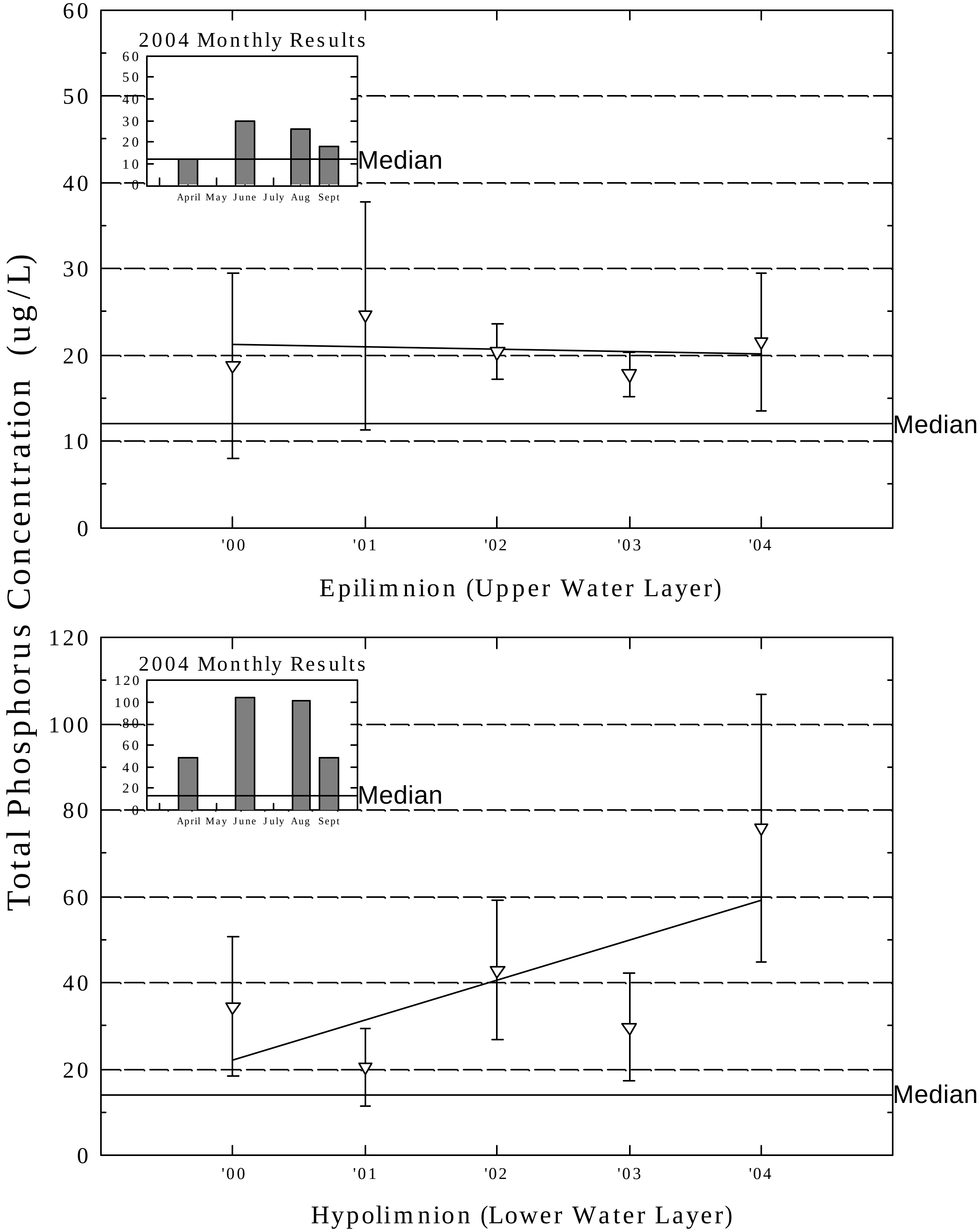
2004 Transparency Results



Historical Transparency Results

Stevens Pond, Manchester

Figure 20. Monthly and Historical Total Phosphorus Data.



SECTION V. POND PROJECT PRIORITIZATION STATUS

Crystal Lake

Goal(s): To maintain fishable and swimmable water quality standards

Water Quality:

1) Address beach parking lot runoff/drainage issues.

2) Address Corning Rd runoff/drainage issues.

1994-1999: The health of Crystal Lake has been the focus of the efforts of the Crystal Lake Preservation Association (CLPA) since their inception in 1994. In 1999, the CLPA was awarded a grant from DES to install a new stormwater treatment system – the StormTreat system. This system now treats runoff from Bodwell Road and adjacent parking areas before it enters the lake. With this installation, one of only three surface water inlets is now being treated.

2002-2004: Comprehensive Environmental, Inc (CEI) was contracted through the SEPP to design plans to address items 1 & 2 above. The final design plans were completed and the projects were put out to bid in 2003. These projects included installation of best management practices (BMPs) at the two remaining outfalls that impacted Crystal Lake.

Best management practices (BMPs) were installed at the City beach on Bodwell Road. Prior to this project, stormwater runoff (contaminated with sediment and other constituents) would flow down gradient from the entrance road to the storm drain network and straight into the lake. To prevent this, the sides of the entrance road were stabilized with filter fabric and crushed stone with perforated pipe drainage systems under them. Deep sump catch basins replaced the existing catch basins and the underground stormwater pipe leading from the parking area to the lakeshore was removed to be replaced by a grassed drainage swale. These measures combined have greatly reduced to volume of runoff that reaches the catch basin network under the parking area and cleaned up any runoff that reaches the lake.

The outfall that drains part of Corning Road is directly adjacent to a highly erodable steep slope. This slope contributed sediment that washed down Corning Road and into the drainage system. The slope also results in the necessity for intensive salt/sand treatment during winter months because of the high occurrence of icing on this section of road. These combined factors had formed a nutrient-rich sediment delta in the Lake at the point of the outfall. At this location, a velocity-reducing device was installed in the form of a baffle box. Due to the steep slope of the area between Corning Road and the shoreline, a baffle tank is called for at the top of the drainage line. The two-baffle system will allow sediment to settle before continuing to the outfall. Installation of curbing along the south side of Corning Road will help prevent sediment eroding from the steep hillside from entering the drainage system.

3) Address *Phragmites* stand by chemical and mechanical treatments.

2004: On September 13th, Municipal Pest Management Services applied an herbicide treatment (Glyphosate, trade name *Rodeo*) on the infested areas of Crystal Lake. Rodeo is similar to the household herbicide *Roundup* and is comprised of a concentrated salt. *Rodeo* quickly breaks down to its raw constituents (carbon dioxide, nitrogen, phosphorus and water) as soon as it contacts water, making it safe for plant eradication in aquatic situations. The Crystal Lake Preservation Association performed the same type of treatment around the lake in 1997.

Mike Morrison applies an herbicide treatment on an invasive Phragmites stand at Crystal Lake. Photo by Art Grindle

Even though the herbicide was only sprayed on *Phragmites* stems, a second treatment may be required in 2005. A 2005 permit application to the N.H. Department of Agriculture is being written. That treatment managed the infestation from spreading for about 5 years. A long-term treatment plan should be developed and implemented with the cooperation of the Crystal Lake Preservation Association, with the goal of complete *Phragmites* eradication.

The dead stalks will be cut and burned after ice-in in 2005. This will remove the seed stock from the site and the nutrient-rich decaying plant material from entering and polluting the lake water.

An area of Phragmites was also dredged near the parking lot drainage entrance into the Crystal Lake 1) Area of Phragmites in lake before dredging; 2) During dredging; 3) Dewatering Phragmites pile after dredging; 4) Area of Crystal Lake free of Phragmites after dredging. Photos by Manchester EPD.

4) Repair StormTreat System by adjusting headbox baffle wall.

After further investigation of the system, it was determined that there was a blockage between the sediment headbox and the StormTreat system. The City's public works department is currently addressing the situation.

Outreach / Education:

1) Continue providing educational materials in kiosk at beach.

2004: A series of color, laminated fact-sheets was created in 2002 and posted in the kiosk during the summer of 2003. These included a map of the waterbody/watershed, fact-sheets on the history of the waterbody, non-point source pollution issues, common exotic plants, and common fish. These were updated in November of 2003 and were posted during the summer of 2004. An additional series of pond-specific fact-sheets were also created in 2004 and will be posted at the kiosk in 2005.

2) Conduct native planting workshop to address intensely-maintained shoreland areas.

3) Provide *Phragmites* education to property owners.

2004: This was re-addressed by an abutter mailing during the spring of 2004.

Recreational:

1) Support project partner efforts to preserve and restore beach house and address parking situation.

Land Preservation:

1) Support the advocacy of land conservation in areas where there is development pressure.

2) Provide careful consideration of land acquisition within the watershed.

2001-2004: CLPA has also been active in attempts to preserve certain tracks of land adjacent to the lake that are threatened by residential development. This area, known as the Filip's Glen subdivision, is the only remaining open space in proximity to the lake. It is important for the long-term health of the lake that this area be developed only in the most environmentally sensitive way possible. The CLPA was able to purchase property proposed for development. The developer has donated the largest wetland portion of the property to the CLPA. This particular portion is the closest to the lake of all the properties in question. A significant amount of the Urban Ponds Restoration Program budget has been allocated for the ultimate purchase and preservation of large portions of the Filip's Glen subdivision property to help preserve the water quality of Crystal Lake.

Dorrs Pond

Goal(s): To restore fishable and swimmable water quality standards.

Water Quality:

1) Address tributary 2E runoff/drainage improvements.

2004: Comprehensive Environmental Inc. (CEI) was contracted through the SEPP to address item #1 above. Designs were completed and the project was put out to bid in early 2004. The east side of Dorrs Pond is heavily developed with residential and commercial land uses. This area drains into a tributary that has contributed pollution to the pond for many years. During the summer/fall of 2004 the three drain lines that feed this tributary have been retrofitted with settling chambers to reduce sedimentation of the pond. Nutrients such as nitrogen and phosphorus are attached to sediment particles, so by reducing sediment, nutrient loading is also reduced. After the stormwater flow exits the chambers, it enters the tributary, which has been altered to further clean the runoff. Large rip-rap was added to reduce flow velocity. Downstream from the rip-rap, a system of biologs and wetland plantings will allow more runoff polishing and nutrient uptake.

A) Brook Channeling; B & C) Biologs in Brook Channel. Photos courtesy of Rob Robinson – Manchester EPD.

2) Address tributary DP3 runoff/drainage improvements.

3) Perform wetland function study in the north end.

4) Perform possible sediment dredging in the north end to lessen nutrient load.

5) Address Goldfish Pond drainage by including outlet in regular sampling schedule and working with Hooksett Conservation Commission.

6) De-Channelize Ray Brook at outlet of Dorrs Pond

Outreach/Education:

1) Retrofit and provide educational materials in kiosk at Livingston Park.

2) Provide fertilizer education through signage at kiosk.

3) Address duck feeding through signage in kiosk and on shore.

2004: A series of color, laminated fact-sheets was created in 2002 and posted in the kiosk during the summer of 2003. These included a map of the waterbody/watershed, fact-sheets on the history of the waterbody, non-point source pollution issues, common exotic plants, and common fish. These were updated in November of 2003 and were posted during the spring of 2004. An additional series of pond-specific fact-sheets were also created in 2004 and will be posted at the kiosk in 2005.

4) Address invasive species through signage at boat ramp and kiosk.

2003: A sign has been placed at the boat ramp stating that Dorrs Pond is currently free of aquatic exotic plants and instructing boaters to remove all plant fragments from their boats to keep exotics out of the waterbody.

5) Address organic debris accumulation at dam through collaboration with Parks & Recreation.

This item is completed annually by the Parks & Recreation Department.

Recreational:

1) Work with Parks & Recreation with trail/Parking lot enhancement projects.

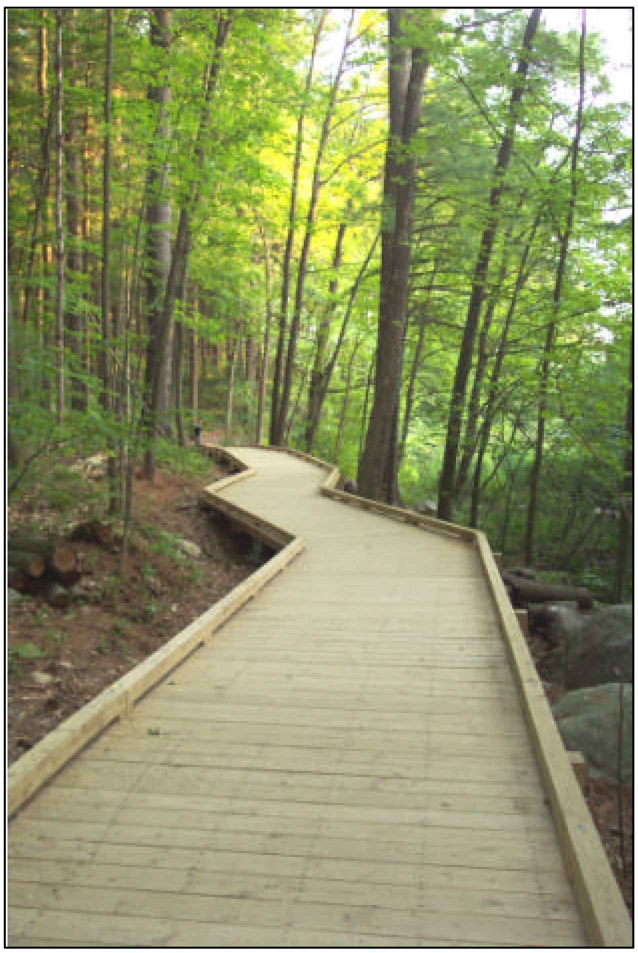
Trail improvements were recently completed around the pond. In 2001, the Manchester Parks Recreation and Cemetery Department received a grant from the Land and Water Conservation Fund to carry out a major trail improvement project at Livingston Park. The grant was matched by a private local fund. The improvement plan consisted of trail improvements, handicap accessibility through approximately 50% of the trail network, boardwalk and bridge construction and viewing areas with benches. Bridges were installed over seasonal stream crossings lessening the likelihood of stream channel disturbance and erosion. The park parking lot now served by a runoff treatment system to treat runoff before it exits into Ray Brook. This project was completed in 2004.

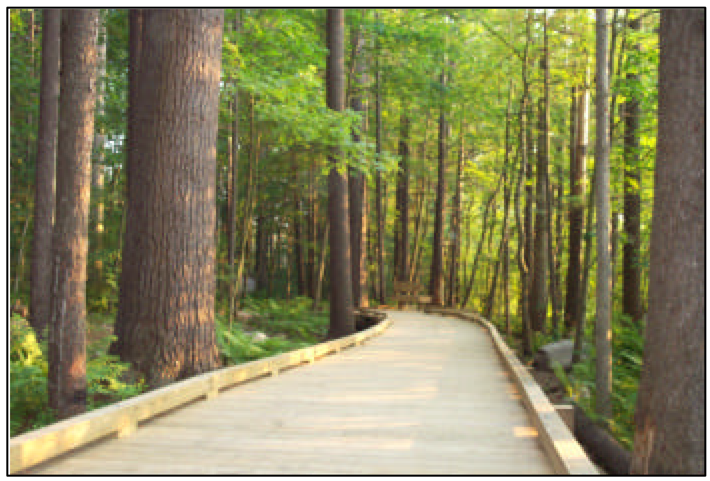
Land Preservation:

1) Support the advocacy of land conservation in areas where there is development pressure.

2) Provide careful consideration of land acquisition within the watershed.

3) Secure adjacent parkland through zoning/easements and possible creation of "Town Forest."





New boardwalk and trails at Dorrs Pond. Photos by Jen Drociak

Maxwell Pond

Goal(s): To assess the feasibility of dam removal and to conduct a habitat assessment.

Water Quality:

1) Conduct a dam removal feasibility study.

2) Address upstream sedimentation.

3) Address apartment complex runoff/drainage issues.

4) Assess habitat enhancement and support an increase of biodiversity.

2001-2004: The City of Manchester *(Lands & Buildings Committee and Mayor & Board of Aldermen*) is faced with making a timely and informed decision about whether to repair and maintain, or remove the dam at Maxwell Pond. The dam is currently in disrepair and no longer fulfills its historical function (ice harvesting in the 1900s).

Aerial of Maxwell Pond, 2004.
Photo courtesy of Pete Walker, VHB.

Maxwell Pond Dam has deteriorated to the point that it needs an estimated $60,000 in repairs. On September 13, 2002 Manchester received an order to repair or remove the dam from the NH Department of Environmental Services, which oversees dam safety. Maxwell Pond does not fulfill a commercial, water supply, or flood control function. Additionally, many of its recreational and aesthetic benefits were lost due to the transport of sediment from upstream and the growth of vegetation around its edges. In 1954 the pond had a maximum depth of 8 feet; today its maximum depth is just 4 feet. Dredging would be required to return the pond to its previous condition. Preliminary estimates indicate that it would cost approximately $1,300,000 to dredge the pond. This would be in addition to the $60,000 to repair the dam, plus ongoing maintenance costs.

Removing the dam would cost an estimated $50,000. While dam removal would not restore swimming, skating and other uses once provided by the pond, it would offer other recreational and aesthetic benefits instead, such as stream-side trails and views of bedrock cascades. Removing the dam would also relieve the City of any future financial and legal liabilities related to the dam, as well as restore Black Brook to its natural free-flowing condition and improve stream ecology, opening up approximately 6 miles of unimpeded anadromous fish passage. Federal and state grant funding is available for dam removal.

Maxwell Pond was created when a dam was built on Black Brook in 1900. The pond, located on Front Street just south of Dunbarton Road, was reportedly named for A.H. Maxwell, owner of the Manchester Coal & Ice Company during the 1930s and 1940s. The company sold ice year-round from its icehouse next to the pond by keeping it cold with hay bales. Until the late 1950s, Maxwell Pond was also a popular place for swimming, picnicking, and fishing. In the winter, the pond provided a spot for skating, bonfires and hockey games. It was also once considered for a secondary municipal water source for the City of Manchester, but the idea was apparently abandoned sometime in the 1960s. Today the dam is owned by the City and managed by the Manchester Parks and Recreation Department.

To date, members of the Manchester Urban Ponds Restoration Program, Manchester Conservation Commission, Parks & Recreation Department, NH Department of Environmental Services, and Trout Unlimited have held two public informational meetings *(May 22, 2003 and January 20, 2005)* and have attended two Lands & Buildings Committee meetings *(August 10th and November 15th 2004)* to provide details on the repair or removal of the dam including costs, benefits and funding sources. A question & answer session and public comment period followed both public informational meetings. Next steps include meeting with the Lands & Buildings Committee again for a recommendation to the full Mayor and Board of Alderman.

Outreach/Education:

1) Construct and provide educational materials in kiosk at Blodgett Park.

2003: An Eagle-Scout constructed a kiosk at Blodgett Park in May 2003. A series of color, laminated fact-sheets was created in 2002 and posted in the kiosk during the summer of 2003. These included a map of the waterbody/watershed, fact-sheets on the history of the waterbody, non-point source pollution issues, common exotic plants, and common fish. These were updated in November of 2003 and were posted during the early summer of 2004. An additional series of pond-specific fact-sheets were also created in 2004 and will be posted at the kiosk in 2005.

2) Examine and address the threat of invasive species.

2004: A partnership between the UPRP, National Park Service (NPS), and the New England Wildflower Society (NEWFS) was developed in 2003 to address invasive species management options on Maxwell Pond's southeast side. NEWFS has drafted a brief work-plan for the field season 2005.

Recreational:

1) Work with Parks & Recreation to construct a boardwalk and loop-trail around Maxwell Pond. This includes a small bridge over Black Brook.

Land Preservation:

1) Secure adjacent parkland through zoning/easements.

1A) Maxwell Pond Dam; 1B) Photo rendering post dam removal; 2A) Maxwell Pond; 2B) Photo rendering post dam removal. Photos courtesty of Jim MacCartney, Trout Unlimited.

McQuesten Pond

Goal(s): To secure conservation easements on private property adjacent to the pond.

Water Quality:

1) **Long Term:** Reduce pavement and restore shoreland in adjacent parking lots.
2) **Short-Term:** Advocate for on-site stormwater treatment systems.

Outreach / Education:

1) Construct and provide educational materials in kiosk at Wolfe Park.
2) Address invasive species through signage at kiosk and mailing to property owners.
3) Address duck feeding through signage at kiosk.

   2003: An Eagle-Scout constructed a kiosk at Wolfe Park in May, 2003. A series of color, laminated fact-sheets was created in 2002 and posted in the kiosk during the summer of 2003. These included a map of the waterbody/watershed, fact-sheets on the history of the waterbody, non-point source pollution issues, common exotic plants, and common fish. These were updated in November of 2003 and were posted during the spring of 2004. An additional series of pond-specific fact-sheets were also created in 2004 and will be posted at the kiosk in 2005.

4) Address adjacent dumpster & lot runoff through business mailings and site visits.

Recreational:

1) Construct a boardwalk at north end of pond.

Land Preservation:

1) Secure conservation easements on private property abutting pond.

   Ongoing: Since McQuesten Pond is largely privately owned, City funded conservation projects are not feasible at this time on most of the pond. The focus remains on obtaining easements or ownership from key property owners of the wetland and open water areas. In the mean time, conservation efforts will continue at the city-owned Wolfe Park side of the pond.

2) Investigate and consider potential for purchasing McQuesten Pond from the abutting landowners

Marty Gavin loads a dump truck with debris from a cleanup at McQuesten Pond.
Photo by Art Grindle

Nutts Pond

Goal(s): To improve sport fishing and non-motorized/recreational boating opportunities. To improve water quality.

Water Quality:

1) Address urban runoff at four outfalls by completing a drainage study.

2) Investigate opportunities for NPS reduction in upper watershed areas.

3) Investigate opportunities to stabilize shoreline with native plantings.

2002-2004: During the winter of 2002 and 2003, Comprehensive Environmental Inc (CEI) conducted a nutrient budget study for the Nutts Pond watershed to help identify the worst pollution sources. The watershed was separated into five subwatersheds and nutrient inputs were calculated according to land use types in each subwatershed. East Inlet subwatershed, the largest subwatershed area (more the 13 million square feet) was found to be the largest contributor of nutrients to the pond (58%). This subwatershed contains extensive athletic fields, large heavily used paved lots, extensive residential neighborhoods, and several strip malls. This area could be the focus for the first BMP installations at Nutts Pond. Recommendations for possible treatment measures were included in a memorandum report by CEI.

Currently, CEI is working on designs for BMP installation in the Precourt Park area. Since the Parks & Recreation Department is planning on improving Precourt Park in 2005, it seemed timely to concurrently address water quality improvements on the pond's north end. Incorporating BMPs into the original park facelift design will save unnecessary duplication of destruction and construction. The BMP design will attempt to divide stormwater volume and infiltrate as much flow as the site allows.

CEI is also working on BMP designs for the north and south inlets. Based on the large drainage areas and anticipated flows, the most cost-effective method to prevent pond sedimentation seems to be to build forebay structures around the inlet structures. This will allow for containment of the sediment to a specific area, which can be cleaned periodically. The accumulated sediment deltas at the north and south inlets will be dredged to remove the nutrient rich material. These projects are scheduled to be constructed in 2005.

Outreach/Education:

1) Retrofit and provide educational materials in kiosk at Precourt Park.

2003 - 2004: An Eagle-Scout retrofitted the kiosk at Precourt Park with corkboard during May, 2003. A series of color, laminated fact-sheets was created in 2002 and posted in the kiosk during the summer of 2003. These included a map of the waterbody/watershed, fact-sheets on the history of the waterbody, non-point source pollution issues, common exotic plants, and common fish. These fact-sheets were updated in November of 2003 and were posted during the spring of 2004. An additional series of pond-specific fact-sheets were also created in 2004 and will be posted at the kiosk in 2005.

2) Provide outreach/education to area businesses through mailings and on-site pollution prevention assessments.

2002-2003: In 2002, the UPRP also created a pollution prevention business survey for facilities within the Nutts Pond watershed. From July through December 2003, 37 (out of 84) businesses in the Nutts Pond watershed were visited. These sites were chosen based on their proximity to Tannery Brook and Nutts Pond.

A few weeks prior to the visits, the businesses were mailed a letter explaining the project. During the visits, the store manager or facilities maintenance person was interviewed. Most businesses visited assessed on general information (whether they were aware of their proximity to Nutts Pond), solid waste/dumpster maintenance, floor drains, stormwater management, use oil, and use and/or storage of any other hazardous materials.

Most of the businesses were retail establishments that did not produce much solid waste and did not deal with any hazardous product storage or waste(s). All of the businesses surveyed were written a thank-you/follow-up letter, given suggestions for areas which needed improvement, and were also given an UPRP sticker for their window.

3) Address dumpster debris at Precourt Park through partnership with Parks & Recreation and Highway Department.

4) Address invasive species through signage at kiosk and at boat ramp.

2001: During a pond survey in 2001, staff from the Urban Ponds Restoration Program identified an exotic aquatic weed, Brazilian Elodea (Egaria densa), growing along the shoreline of Nutts Pond. This was the first confirmed occurrence of this plant in New England waters. Egaria densa is an extremely invasive aquatic plant (similar to variable milfoil) that rapidly outcompetes native submerged aquatic vegetation and radically alters aquatic habitat.

2003: With funding from the NH Department of Environmental Services, Nutts Pond was treated by Lycott Environmental with an aquatic herbicide in June 2003. Signs were also posted at the boat launch.

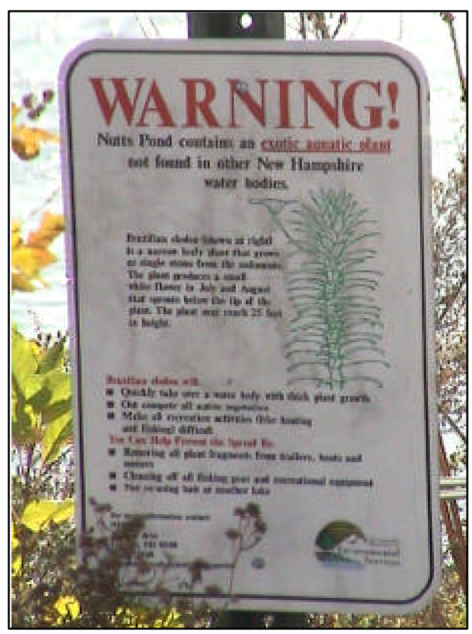
2004: During the summer of 2004, only 2 individual *Egaria densa* plants were detected in, and removed from, Nutts Pond. Thus, the treatment seems to be a sccess! Ken Warren, Aquatic biologist responsible for aquatic weed control at NHDES stated that "The early detection of this invasive plant by the Manchester Urban Ponds staff allowed for a successful herbicide treatment of the pond". Warren further stated that "Left undetected this troublesome South American weed would have infested other nearby urban ponds as well as other waterbodies within the state." Staff from UPRP will continue to monitor Nutts Pond to ensure that this invasive weed does not make a comeback.

Recreational:

1) Partner with Queen City Trails Alliance/Manchester Rails-To-Trails to enhance pond circuit trail.

2) Investigate use of and potentially improve boat-launch.

Lycott Lake and Pond Management applies an herbicide on Nutts Pond to control the invasive aquatic plant Brazillian waterweed (Egaria densa). Photos by Jen Drociak



Brazillian Waterweed Sign at Nutts Pond. Photo by Art Grindle

Pine Island Pond

Goal(s): To maintain fishable and swimmable water quality standards and to improve fish habitat.

Water Quality:

1) Stabilize Cohas Brook streambank areas.

2) Address sedimentation at Cohas Brook where it enters Pine Island Pond.

2004: This project idea has been included on a short list of projects proposed for the remaining SEPP funds. If budgeting allows, this project will be pursued in 2005.

Photo by Art Grindle

Outreach / Education:

1) Retrofit and provide educational materials in kiosk at Pine Island Park.

2003: An Eagle-Scout retrofitted the kiosk at Pine Island Park with corkboard during May, 2003. A series of color, laminated fact-sheets was created in 2002 and posted in the kiosk during the summer of 2003. These included a map of the waterbody/watershed, fact-sheets on the history of the waterbody, non-point source pollution issues, common exotic plants, and common fish. These fact-sheets were updated in November of 2003 and were posted during the spring of 2004. An additional series of pond-specific fact-sheets were also created in 2004 and will be posted at the kiosk in 2005.

2) Address accelerated plant growth through fertilizer education to property owners.

2003-2004: This has been addressed by educational direct mailings to pond abutters in 2003 and 2004.

3) Address invasive species at Cohas Brook through volunteer maintenance efforts.

2004: Volunteers have been monitoring water quality and hope to form a "Weed Watcher" effort in order to stay abreast of invasive aquatic species at Pine Island Pond.

4) Support other entities to address boat wake issues.

Recreational:

1) Assess feasibility of fish ladder at dam with NHFG.

Other:

1) Form Pond Association & Develop Watershed Management Plan.

2004: The Pine Island Pond Environmental Society (PIPES) was formed in September 2004 as a means for area residents to help preserve the quality of life in their neighborhood. The group's purpose is to foster the protection and preservation of Pine Island Pond. The PIPES Political Action Committee currently has 18 members and continues to grow. PIPES has been motivated by a number of issues including declining water quality of Pine Island Pond, impacts from unscheduled draw-downs, land development, invasive aquatic plants, and many others. The unscheduled draw-down that drained the pond last June energized pond residents to take action. Certain members of PIPES have been working for pond conservation for quite some time conducting water quality monitoring and historical research. Volunteers at Pine Island Pond have been involved with the NH Volunteer Lakes Assessment Program (a program coordinated by NH DES) for five years. For this program, volunteers assist staff from the Manchester Urban Ponds Restoration Program in collecting monthly pond samples for water quality tracking.

Stevens Pond

Goal(s): To improve water quality through a partnership with the New Hampshire Department of Transportation to address highway runoff.

Water Quality:

1) Address and remedy I-93 runoff issues.

2001-2004: Since 2001, several agencies have been working on a solution to the highway runoff issue at Stevens Pond. The NH Department of Transportation has expressed willingness to work with DES and the UPRP to treat the highway runoff that is drastically affecting the water quality of Stevens Pond. Proposed solutions include a closed drainage system to divert stormwater to where adequate treatment can be attained, or a berm diversion system to separate the stormwater from Stevens Pond. Discussions with NH DOT are still ongoing.

Fishermen on Stevens Pond. Photo by Art Grindle

2) Address headwater erosion at EJ Roy Drive and other developed areas.

Outreach / Education:

1) Construct and provide educational materials in kiosk at boat launch.

2) Address invasive species with proper signage at kiosk and boat launch.

2003: An Eagle-Scout constructed a kiosk at the Stevens Pond boat ramp during May, 2003. A series of color, laminated fact-sheets was created in 2002 and posted in the kiosk during the summer of 2003. These included a map of the waterbody/watershed, fact-sheets on the history of the waterbody, non-point source pollution issues, common exotic plants, and common fish. These fact-sheets were updated in November of 2003 and were posted during the spring of 2004.

2003: A sign has been placed at the boat ramp stating that Stevens Pond is currently free of aquatic exotic plants and instructing boaters to remove all plant fragments from their boats to keep exotics out of the waterbody.

Recreational:

1) Improve boat-launch.

2) Work with Parks & Recreational Department to create a wetland boardwalk.

3) Improve adjacent trails.

2004: These project ideas have been included on a short list of projects proposed for the remaining SEPP funds. If budgeting allows, these projects will be pursued in 2005.

Land Preservation:

1) Secure adjacent parkland through zoning/easements.

APPENDIX A. NEWSLETTERS, FACT-SHEETS & PUZZLES

APPENDIX B: GLOSSARY

Acid Neutralizing Capacity - Acid Neutralizing Capacity (ANC) describes the ability of water to buffer against acidic inputs, such as acid rain. This is also known as a lake's alkalinity. The higher a water body's ANC, the better it's ability to buffer acidic inputs. Lakes with low ANC, typical of New Hampshire, are especially vulnerable to the effects of acid precipitation.

A desirable ANC for any lake is greater than 20 mg/L of Calcium carbonate (CaCO). The average ANC for New Hampshire lakes is 6.5 mg/L. (NHDES, 1999.) The average ANC for Manchester's ponds is 19.5 mg/L.

Chlorophyll-*a* - Chlorophyll-*a* - The concentration of chlorophyll-a is an indicator of algal abundance. Because of the presence of chlorophyll-a pigment in algae, the relative concentration of chlorophyll-a in the water gives an indication of the concentration of algae. As the alga population increases, so does the chlorophyll-a concentration.

Chlorophyll-*a* concentrations greater than 10.0 mg/m^3 usually indicate an algal bloom. The mean chlorophyll-*a* value for New Hampshire lakes is 7.47 mg/m^3. (NHDES, 1999.) The mean chlorophyll-*a* concentration for Manchester's ponds is 9.36 mg/m^3.

Similar to the summer of 2001, the summer of 2002 was filled with many warm and sunny days and there was a lower than normal amount of rainfall during the latter-half of the summer. The combination of these factors resulted in relatively warm surface waters throughout the state. The lack of fresh water input to the lakes/ponds reduced the rate of flushing which may have resulted in water stagnation. Due to these conditions, many lakes and ponds experienced increased algae growth, including filamentous green algae (the billowy clouds of green algae typically seen floating near shore), and some lakes/ponds experienced nuisance cyanobacteria (blue-green algae) blooms.

Conductivity - Conductivity, also known as specific conductance, is a measure of the ability of water to conduct an electric current. This is determined by the number of ionic particles present in the water. High conductivity values may be indicative of non-point source pollution (i.e. polluted runoff), but may be affected even more dramatically by natural geologic features of the watershed.

Conductivity values for New Hampshire lakes that are greater than 100 micro Mhos (uMhos) are most likely indicative of anthropogenic sources of excess ions in the water, since the average conductivity for New Hampshire lakes is 56.8 uMhos. Anthropogenic sources include urban runoff (metals from cars, sodium from road salt), and agricultural runoff (sediment from erosion, phosphorus from fertilizers and animal wastes). (NHDES, 1999.) The average conductivity for Manchester's ponds (epilimnion or upper layer) is 611.9 uMhos.

Typically, sources of increased conductivity are due to human activity. These activities include septic systems that fail and leak leachate into the groundwater (and eventually into the tributaries and the lake/pond), agricultural runoff, and road runoff (which contains road salt during the spring snow melt). New development in the watershed can alter runoff patterns and expose new soil and bedrock areas, which could contribute to increasing conductivity. In addition, natural sources, such as iron deposits in bedrock, can influence conductivity. It is possible that the lower than normal amount rainfall during the latter-half of the summer reduced tributary and lake flushing, which allowed pollutants and ions to build up and resulted in elevated conductivity levels.

Dissolved Oxygen (DO) - Dissolved oxygen levels are key to the health of a pond ecosystem. Fish and other aquatic organisms need dissolved oxygen to breathe. At colder temperatures, water holds more oxygen than at warmer temperatures. Bacteria and other pollutants can also "use up" dissolved oxygen, through decomposition, the process of biological breakdown of organic matter (i.e.; biological organisms use oxygen to break down organic matter). Thus, summer dissolved oxygen concentrations are typically lower than those collected in cooler months, and deeper readings are higher than more shallow readings

A dissolved oxygen and temperature profile is determined by measuring DO and temperature at each meter of depth from the water's surface to the pond bottom. Pond stratification occurs when different temperatures exist at the top (epilimnion), middle (metalimnion), and bottom (hypolimnion) layers of the water column. Generally, the deeper a body of water, the more pronounced the stratification may become. This is mainly influenced by the amount of solar energy that reaches each water layer. As the sun becomes lower in the sky in the fall, thermal stratification lessens and usually disappears completely by winter. Deeper ponds experience pronounced thermal stratification, while in shallower ponds stratification is subtler, if present at all. Due to biological processes that consume oxygen at the pond bottom, some ponds incur a dissolved oxygen deficit in the hypolimnion (bottom layer).

"Typically, the deeper the reading, the lower the percent saturation of oxygen. Colder waters are generally able to hold more dissolved oxygen than warmer waters, and generally, the deeper the water, the colder the temperature. As a result, a reading of 9 milligrams/Liter (mg/L) of oxygen at the surface will yield a higher percent saturation than a reading of 9 mg/L at 25 meters, because of the difference in water temperature." (NH DES, 1999).

Epilimnion (Epilimnetic) – Top layers of a lake (having to do with the top layers of a lake).

Hypolimnion (Hypolimnetic) – Bottom layers of a lake (having to do with the bottom layers of a lake).

Mean – The value directly in the middle. The value for which there are equal values above and below. For instance, the mean Chlorophyll a concentration for NH lakes is the concentration for which there is an equal number of lakes with greater concentration and lakes with a lower concentration.

Metalimnion (Metalimnetic) – Middle layers of a lake (having to do with the middle layers of a lake).

pH - The lower the pH of water, the more acidic the water. The higher the pH of water, the more alkaline the water. Pond pH is crucial to the well being of pond dwelling organisms. A pH of less than 5.5 (acidic) has detrimental effects on fish growth and reproduction. A pH between 6.5 and 7.0 is considered ideal for freshwater ecosystems. The median pH for New Hampshire lakes is 6.7. (NHDES, 1999). The median pH for Manchester's ponds is 7.07.

Phosphorus - Phosphorus is a necessary nutrient for plant and algae growth. It is generally "limiting" in New Hampshire waters, meaning that plants have plenty of everything else, and only the amount of phosphorus present keeps their growth in check. Too much phosphorus in a lake/pond can therefore lead to unhealthy increases in plant and algal growth. The median summer total phosphorus concentration in the epilimnion (upper layer) of New Hampshire's lakes and ponds is 11 ug/L. The median summer phosphorus concentration in the hypolimnion (lower layer) is 14 ug/L.

Phosphorus exists as a natural element, but becomes a problem when inputs from such sources as septic systems, erosion, animal wastes, and fertilizer load the water body with excess amounts. One of the most important approaches to reducing phosphorus loading to a waterbody is to continually educate watershed residents about its sources and how excessive amounts can adversely impact the ecology and value of lakes and ponds. Phosphorus sources within a lake or pond's watershed typically include septic systems, animal waste, lawn fertilizer, road and construction erosion, and natural wetlands.

Secchi Disk Transparency - A Secchi disk measures the depth that one can see into the water, and so the depth that sunlight can reach into the water. Although a low Secchi disk transparency is not necessarily "bad", a change in transparency over time is undesirable, because it may cause plants and animals currently living in the pond to die off or may cause a change in the pond life diversity. To measure Secchi disk transparency, a black and white patterned disk is lowered into the water, and the depth at which it is no longer visible is recorded. This indicates water clarity, which is affected by the amount of algae and particulate matter (turbidity) in the water column. Secchi disk readings are somewhat subjective, but generally correlate with chlorophyll-*a* concentrations and turbidity levels.

The mean transparency for New Hampshire lakes is 3.7 meters. (NHDES, 1999.) The mean transparency for Manchester's ponds is 2.1 meters. If we assume that Manchester's ponds were originally more typical of New Hampshire lakes, then we would estimate that they are more "cloudy" than they should be. Steps to decrease turbidity and increase transparency/clarity (i.e. reducing polluted runoff entering the ponds, and stabilizing banks) are therefore being planned.

Two different weather-related patterns occurred during the spring and summer of 2002 that influenced lake quality during the summer season. In late May and early June, numerous rainstorms occurred. Stormwater runoff associated with these rainstorms may have increased phosphorus loading, and the amount of soil particles washed into waterbodies throughout the state. Some lakes and ponds experienced lower than typical transparency readings during late May and early June.

However, similar to the 2001 sampling season, the lower than average amount of rainfall and the warmer temperatures during the latter-half of the summer resulted in a few lakes/ponds reporting their greatest-ever Secchi-disk readings in July and August (a time when we often observe reduced clarity due to increased algal growth)!

Typically, high intensity rainfall causes erosion of sediments into lakes/ponds and streams, thus decreasing transparency and clarity. Efforts should continually be made to stabilize stream banks, lake/pond shorelines, disturbed soils within the watershed, and especially dirt roads located immediately adjacent to the edge of tributaries and the lake/pond. Guides to Best Management Practices designed to reduce, and possibly even eliminate, nonpoint source pollutants, such as sediment loading, are available from NHDES upon request

Turbidity - Turbidity is a measure of suspended matter in the water. The more material (clay, silt, algae) suspended in the water, the higher the turbidity. These materials cause light to be scattered and absorbed, instead of transmitted in straight lines, leading to decreased water transparency/clarity. High turbidity readings are often found in water adjacent to construction sites, or waters otherwise polluted. (NHDES, 1999.)

The median turbidity for New Hampshire lakes is 1.0 NTU. (NHDES, 1999.) The median turbidity for Manchester's ponds is 1.55 NTU.

APPENDIX C:
UPRP POND SAMPLING PROCEDURE BASED ON NH VLAP PROTOCOL

General

1. All bottles must be labeled with: pond name, city, date, time, and sample description.
2. Locate the deepest spot in the pond using map provided. Drop anchor and verify with depth finder.

Dissolved Oxygen/Temperature Profile:

1. Inspect the probe membrane. No are bubbles should be present.
2. Turn the unit on (set knob to "calibrate"). The YSI 52 Meter will perform a self-check. Moisten the sponge in the cap on the DO probe. Reattach the cap leaving a small space between the sponge and the probe. Press confirm when prompted. Press confirm again when "Enter cal value Last = 100%" appears. The meter will indicate when calibration is complete.
3. Take surface reading (submerge the probe just under the water's surface). Record on data sheet.
4. Take readings at each meter to within 1 meter of the bottom. Record these on the data sheet.
5. Take note of temperature readings that differ by more than 1 degree celcius between meters. Once a significant temperature drop is observed, the temp. will continue to fall meter by meter until the temp. levels off. The first point where the temp. drops by 1 degree or more is the bottom of the top water layer (*epilimnion*). The point where the temp. levels off after steadily dropping is the bottom of the middle layer (*metalimnion* or *thermocline*). The bottom layer is the *hypolimnion*. Identify the midpoint depth of each layer and record this on the data sheet in the area labeled "sample depths".

Kemmerer Bottle:

1. Using the Kemmerer Bottle, collect samples from the midpoint of each water layer. These samples are placed in the large white (opaque) bottles. Be sure to rinse these bottles with pond water before filling. Also fill the small brown bottles using these samples (do not rinse these bottles; contain strong acid preservative).

Composite Sample:

1. Rinse the bucket with lake water and discard over side of boat.
2. Take one Kemm. Bottle sample at each meter beginning at the midpoint of the middle layer and working up to 1 meter. If the pond is not stratified, start at 2/3 of the pond depth and work up to 1 meter.
3. Empty half of the Kemm. Bottle sample from each depth into the bucket and discard the rest. Mix well.
4. Rinse the large brown bottle with water from the bucket and discard. Then fill the bottle to the top. Label the bottle "____M Comp" indicating the deepest point at which the composite was started.

Plankton Sample:

1. Collect a sample of plankton using the plankton net.
2. Be sure the clamp is closed at the net outlet. Lower the net to the midpoint of the middle layer and retrieve slowly and steadily. When net reaches the surface rinse the plankton down the sides by dipping the net repeated, being careful not to submerge completely.
3. Raise the net from the water and gently swirl it in a circular fashion to concentrate the plankton.

4. Empty the contents into one of the glass bottles by releasing the clamp on the hose at the bottom of the net. Close the clamp when finished.

5. Lower the bottom portion of the net into the water, raise and swirl again. Release the clamp and empty contents into the same glass bottle. This rinses remaining plankton off the net, and into the sample.

6. Repeat steps 2 through 5. This time add three drops of Lugall's solution (brown liquid in the small glass vial) to the second sample and slightly agitate the sample. The correct amount of Lugall's solution should make the sample tea-colored.

7. Label both glass bottles "____M Vert" indicating the depth at which you started the haul.

Secchi Disk:

1. Lower the secchi disk over the shady side of the boat until it disappears from sight.

2. Slowly raise the disk until the white is just visible. Note the depth at which this occurs. Record the average of these two points.

3. Repeat this process yourself, or by another monitor. Record both transparency readings on the Field Data Sheet, then calculate the average.

Inlet & Outlet Sample Collection:

1. At each designated inlet and outlet fill a large white bottle and a small brown bottle.

2. Label these bottles "______ Inlet", or "______ Outlet".

3. Be sure the water is flowing. Samples should not be taken from a stream that is stagnant. Be careful not to agitate the water upstream from where the sample is to be obtained.

4. Rinse the white bottle using stream water and discard rinse water downstream from sample location.

5. Collect sample by dipping the white bottle under the surface, being careful not to disturb the bottom.

6. Fill the small brown bottle to the neck with water from the white bottle. **Do not** rinse the small brown bottles.

7. Dip the white bottle again to refill.

Complete the Field Data Sheet (observations, stream flow, etc.). Store samples in a cooler with ice and transport to Concord DES Laboratory **within 24 hours**. Be sure the samples arrive in time to be analyzed that day (**before 2:00 PM**).

APPENDIX D: WATER QUALITY DATA SPREADSHEETS